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AN ANALYSIS OF THE FACILITY
PREVENTIVE MAINTENANCE PROGRAM
AT THE U.S. NAVAL ACADEMY

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by

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B.S. Ocean Eng., U.S. Naval Academy
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AN ANALYSIS OF THE FACILITY PREVENTIVE MAINTENANCE PROGRAM AT THE U.S. NAVAL ACADEMY

by

JOHN MICHAEL KUCINSKI

Submitted to the Department of Civil Engineering on August 9, 1985 in partial fulfillment of the requirements for the Degree of Master of Science in Civil Engineering

ABSTRACT

An analysis of the U.S. Naval Academy's building equipment preventive maintenance program was conducted. The equipment of six buildings of various ages and uses, and typical of buildings found at most Navy bases, were selected for study. The analysis included an investigation into the relationships between equipment failure and age, preventive maintenance inspections and equipment failure, and preventive maintenance actions and equipment failure. Management issues regarding the preventive maintenance program were also examined.

The results of the analysis indicated that the Academy was over-maintaining some of its mechanical equipment. This was proven by applying cost and linear regression analysis techniques to the equipments' history records which included periods of both high and low accomplishment rates of preventive maintenance. There were also some significant deficiencies noted in the computerized and manual management systems used in the administration of the preventive maintenance program. Specific recommendations for program improvement as well as a proposal for an ideal preventive maintenance program were provided.

Thesis Supervisor: David H. Marks

Title: Professor of Civil Engineering

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ACKNOWLEDGMENTS

First I would like to acknowledge my lovely wife, Irene, who provided me with more love and support than I ever dreamed possible. It is to her that this thesis is dedicated.

I would also like to thank the people in Public Works at the Naval Academy; Captain Buffington, Lieutenant Joe Walbert, Ralph Hamilton, Dick Fernald, Al Agachinsky, Steve Grant, and especially Darryl Malecki; for providing me the opportunity to dissect a piece of their business. When I was stationed at the Academy, preventive maintenance was an area I always meant to look into, but never found the time to investigate (just like maintenance managers everywhere). Since I left the Academy about a year ago, the maintenance managers there have been attacking the issues with a vengeance. Some of my findings and recommendations presented in this thesis may seem a bit contrary to accepted views, and I may have been a tad blunt in some of my constructive criticism. I certainly didn't mean to jeopardize any friendships, but rather encourage continued discussion on the subject of preventive maintenance. The people involved in maintenance at the the Academy are true professionals and, as this thesis was designed to help them, I hope I've been able to deliver a useful product.

Lieutenant Paul McMahon of the CEC Detail Office deserves a special note of thanks for providing the funding support for my junkets to Annapolis. I hope he finds the Navy got its money's worth when he reads this.

Another debt of gratitude goes to Lieutenant Rich Cellon and his wife, Carmen, for their hospitality in Annapolis. I never knew low-cholesterol food could taste so good.

The counsel and help provided by Rear Admiral Fraser and his staff at OP-44, and Captain Drennon and Commander Tom Tanner at NAVFAC were invaluable and much appreciated.

Statistically speaking, without John Uppgren's extremely beneficial and freely given help at MIT, I probability wouldn't have finished this project.

I'd also like to thank my Army buddies at MIT. If it weren't for Captains Bill Seymour and Rick Davis, I would have had a much tougher time making it through the graduate program. I also probably would have finished my thesis in about half the time it took. BEAT ARMY!

Last, but certainly not least, I would like to thank my advisor, Dave Marks, for his outstanding support throughout the year. He once compared my desire of taking a wide range of MIT courses in a year to the predicament faced by a kid in a candy store. Here's the result of my shopping. Thanks, Dave.

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CHAPTER 1 INTRODUCTION

Equipment preventive maintenance (PM) systems are widely accepted and used for reducing overall equipment life cycle costs. These costs include those associated with the equipment's acquisition, operation, maintenance and repair. PM is commonly considered to involve necessary support actions such as equipment cleaning, adjustment, replacement of disposable parts, and minor repairs resulting from some form of equipment inspection. Successful PM programs are rare because maintenance managers are universally overworked, provided inadequate resources to work with, and are given an overwhelming maintenance workload backlog (Harris, 1983).

The U.S. Navy requires its managers to include facility maintenance as one of their top priorities, but building equipment maintenance is sometimes neglected, primarily because its effects are not immediately apparent. An excellent example of this is found at the U.S. Naval Academy in Annapolis, Maryland. The facilities at the Academy are beautifully maintained, but the equipment inside the mechanical rooms of these facilities is sometimes overlooked.

The Academy's preventive maintenance inspection program provides the framework within which equipment preventive maintenance is scheduled and performed. It is currently being critically reviewed by the maintenance

managers responsible for its planning and execution. Two hypotheses regarding the program will be tested as a way of complementing the Academy's efforts to identify and resolve PM problem issues. First, preventive maintenance scheduling techniques appear to result in excessive maintenance being performed on the equipment. In order to determine this hypothesis' validity, linear regression analysis techniques will be used to examine the equipment's historical relationships between equipment failure and age, preventive maintenance inspections and equipment failure, and preventive maintenance actions and equipment failure. The cost of doing preventive maintenance will also be explored. The second hypothesis is that equipment maintenance suffers as a result of administrative barriers. Comparison of the Academy's program with PM managerial issues presented in the literature will be done.

Subsequent chapters will be dealing with the different aspects of equipment maintenance in some detail. Chapter 2 provides a background into general PM terminology and concepts. In addition it also describes both theoretical and practical PM policies which are generally accepted and widely used. Chapter 3 describes the Academy's PM program including overall scope, management techniques and administrative procedures. Building on the information of the previous two chapters, the analysis of the Academy's program is performed in Chapter 4. The methodology used in acquiring the data and the analyses themselves are

presented. Equipment history, PM program cost information and management methods are investigated. Specific recommendations for improvements within the existing PM program are offered. Chapter 5 presents a proposal for an ideal PM system at the Naval Academy. Because of its significant shift from the way the program is now established, implementation barriers are identified and recommendations for realization are provided. It is felt that many of the ideal program's features are applicable to a broad spectrum of equipment maintenance programs at agencies both inside and outside of the Navy. Chapter 6 provides a management-type summary of the conclusions and recommendations of the previous chapters.

CHAPTER 2 PREVENTIVE MAINTENANCE THEORY

Preventive maintenance events are those routine, repetitive actions such as equipment inspection, testing, lubrication, cleaning, minor adjustments and minor part replacements, which together share the goal of extending building equipment life and avoiding unanticipated equipment failure. Some of the significant factors leading to equipment failure include the adverse effects of the environment, overload conditions, equipment misalignment, equipment age, externally imposed physical damage, lubrication inadequacy, and general material degradation. As costs are involved with equipment failure, PM is ideally designed to lower overall life cycle costs associated with equipment operation. These costs include not only direct equipment and PM labor and overhead costs, but also the indirect costs resulting from the disruption in services provided by the equipment. PM scheduling aspects, record keeping requirements and management reporting systems are topics that have been discussed frequently in the literature. To date much of what has been written has either been very theoretical regarding scheduling frequency of electronic equipment and authored by operations research analysts, or very practically oriented and authored by physical plant managers concerned with relatively simplistic matters such as paperwork format and control procedures. Only recently does it appear that the gap

between these two extremes is being bridged in the area of facility equipment with the application of reliability centered maintenance to physical plants. This chapter will present a review of some of these PM concepts as they apply to facility equipment.

2.1 Preventive Maintenance Concepts

There are a number of ways to approach the equipment maintenance problem. One possibility is to do no preventive maintenance and react to each equipment casualty in a crisis management style, performing corrective maintenance or replacement only at the time of the casualty. A second alternative involves an austere inspection program whereby infrequent observations are made to determine which pieces of equipment are in the worst shape, and then scheduling them for appropriate maintenance or replacement actions on a priority basis. Thirdly, opportunistic maintenance could be done by scheduling maintenance on equipment to coincide with a major system overhaul. Still another option is to periodically replace equipment strictly on the basis of its age. Finally some form of preventive maintenance inspection could be scheduled, with resulting maintenance actions being performed which would enhance the safety, reliability and operating economy characteristics of the equipment (Steinthal, 1984).

As in almost any field of endeavor, the goals of a good maintenance program should include maintenance

efficiency, operations effieciency and fiscal efficiency (U.S. National Bureau of Standards, 1982). A proper combination of the approaches mentioned above, tailored to an agency's individual circumstances, would greatly assist in the attainment of those goals. Little has been done in the past by maintenance managers to upset already implemented and accepted, but not necessarily effective equipment maintenance policies. In all fairness most maintenance managers are very capable people who are faced with recurring limitations in human resources, bureaucratic efficiency, organization adaptation, equipment maintainability, physical environment, and funding support in all their areas of responsibility (James and Green, 1979). PM is usually and unfortunately ignored or relegated to a low priority because its benefits are not always immediately apparent or fully appreciated by the maintenance manager's supervisors. Subsequently, risk and the rate of equipment failure increase due to a lack of maintenance attention, and a viscious circle ensues as more and more resources are devoted toward breakdown maintenance. The end result is a costly maintenance operation because of increased inefficiency.

The cornerstone of an equipment maintenance program is preventive maintenance. PM programs typically feature scheduled PM inspections, the frequency of which are often based on ultraconservative and antiquated estimates of the needs of the equipment. Under such systems, emphasis has

been placed on getting the mechanic to do things right, but little attention has been paid to doing the right things (Smith and Matteson, 1985). The following sections in this chapter will touch on the theoretical concepts and alternative PM policies currently available to maintenance managers.

2.2 Theoretical Preventive Maintenance Policies

Theoreticians use mathematical models to try to describe events which occur in the real world. Maintenance models are designed subject to the following conditions: a)state of the system including age and overall condition; b)maintenance actions available, e.g., inspect, repair and/or replacement; c)time horizon involved; d)knowledge of the system including costs and failure distribution; e)type of model, i.e., stochastic or deterministic; f)objective of the system model; and g)methods of solution, e.g., linear regression (Perskalla and Voelker, 1976). In general, equipment maintenance models can be classified into two broad categories: preparedness models and preventive maintenance models. In each type, equipment is assumed to fail stochastically. Preparedness models further assume that the actual state of the equipment is not known with any certainty, while preventive maintenance models assume that the state is known with certainty. States are bounded by "new" and "failed" conditions with different degrees of deterioration reflecting intermediate states. Equipment condition movement from state to state is governed by

probability mechanisms which are either known, partially known, or unknown (McCall, 1965).

The choice of a failure distribution which accurately describes equipment behavior is difficult and often dependent upon individual equipment and system characteristics. For the purposes of this thesis, data analysis will be performed using linear regression with some comparison made to the characteristics of the Weibull distribution.

The Weibull distribution is an accepted distribution used to deal with complicated systems whose operation relies on the individual components that make up the system. Dynamic equipment falls within this category. The Weibull distribution is defined by its density function which is

$$f(t) = \alpha\beta t^{\beta-1} e^{-\alpha t^{\beta}}, \quad t>0, \alpha>0, \beta>0$$
$$= 0 \qquad\qquad\qquad , \quad t \le 0$$

The graphs of the density function are provided in figure 2-1. The resulting hazard or failure rates as defined by

$$r(t) = \beta\alpha t^{\beta-1}, \quad t>0$$

shows the failure rate of equipment for different values of beta. Summing the curves of figure 2-2 in figure 2-3, the so called "bathtub" curve results. Intuitively this curve is easy to accept because new equipment experiences failure at a faster rate due to the cumulative effects of chance and the inherent "bugs" present in such equipment. The

Figure 2-1. Weibull Distributions

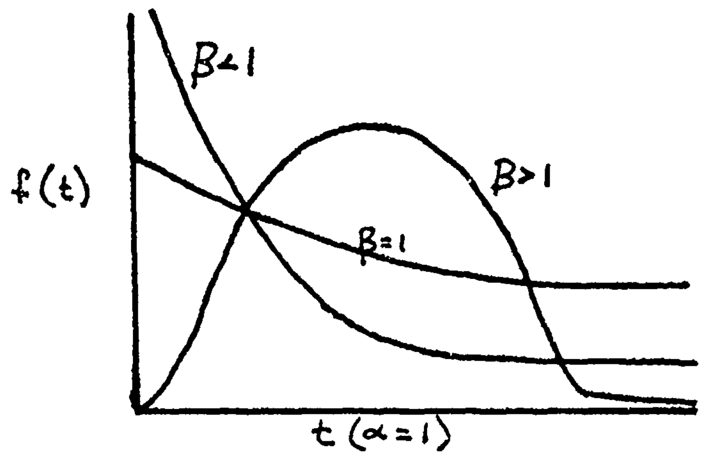


Figure 2-2. Weibull Hazard Rates

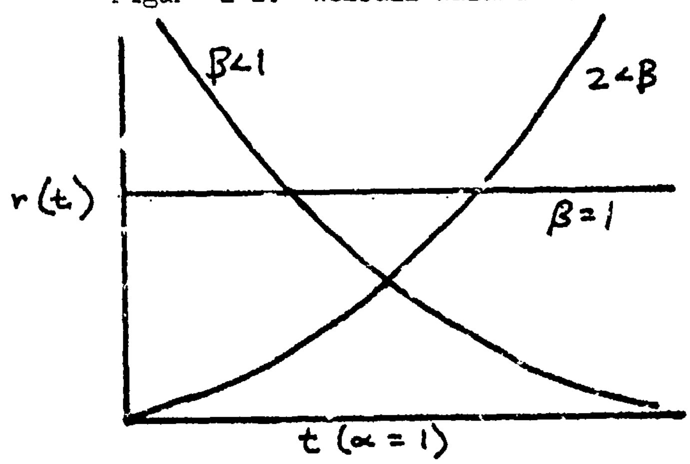
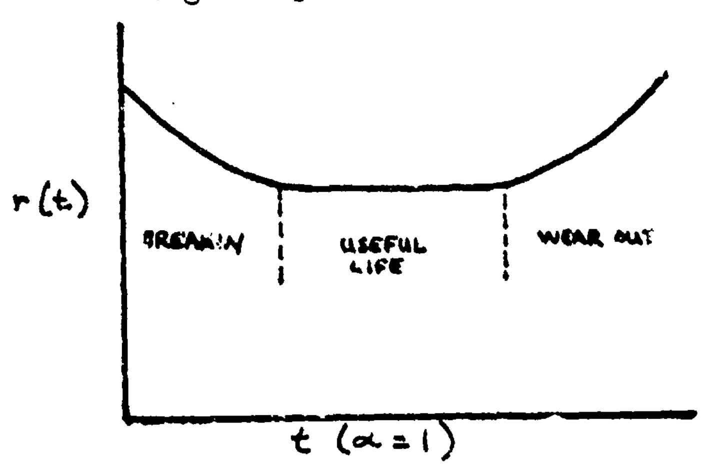


Figure 2-3. Bathtub Curve



equipment then fails at a constant rate by chance until it begins to wear out at a faster rate due to the added condition of advanced age.

PM should positively affect the performance of equipment. Generally PM is broken down into two categories: PM inspections and PM actions. PM inspections involve little more than an aural and visual observation of the equipment in operation, perhaps augmented by some small maintenance task such as minor lubrication. PM actions go beyond inspections to the next level of maintenance when the equipment requires minor repairs or adjustments. A re-tightening of a ventilation unit's fan belts is an example of a PM action. Figures 2-4 and 2-5 graphically indicated how PM inspections and actions might conceivably affect equipment performance as compared to the number of breakdowns. More PM should usually result in fewer breakdowns than would occur if little or no PM was performed. PM actions should have a more positive effect than PM inspections, and the relative slopes of the curves indicate this. The relationship between PM and breakdowns is assumed to be linear since it is mathematically simple to determine and yet still accurate enough for the practical purposes of analyzing the effects of the Naval Academy's PM program on equipment performance.

2.3 Practical Preventive Maintenance Policies

A preventive maintenance program can be based on periodicity or equipment condition, or a combination of the

Figure 2-4. Effect of PM Inspections on Breakdowns

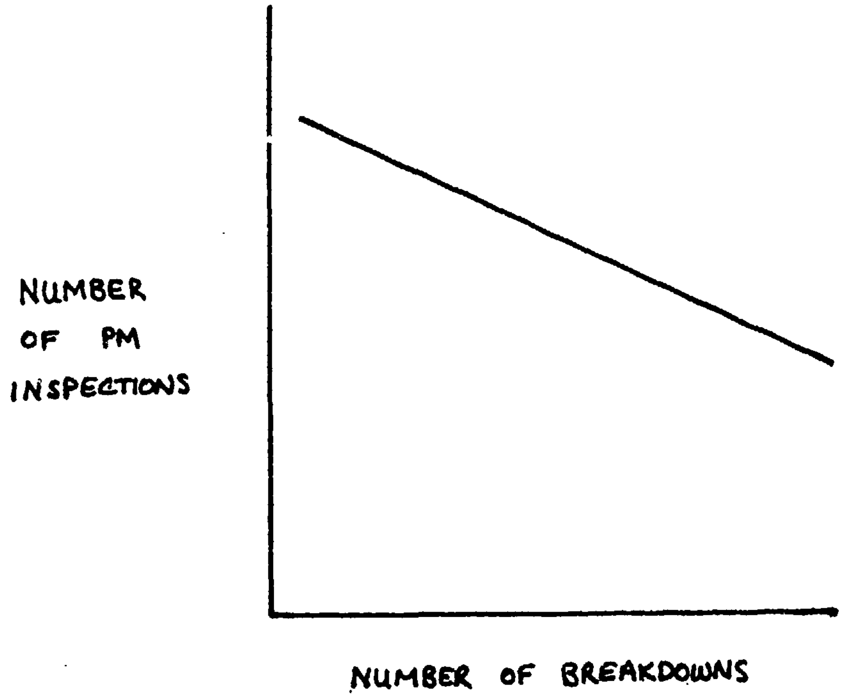
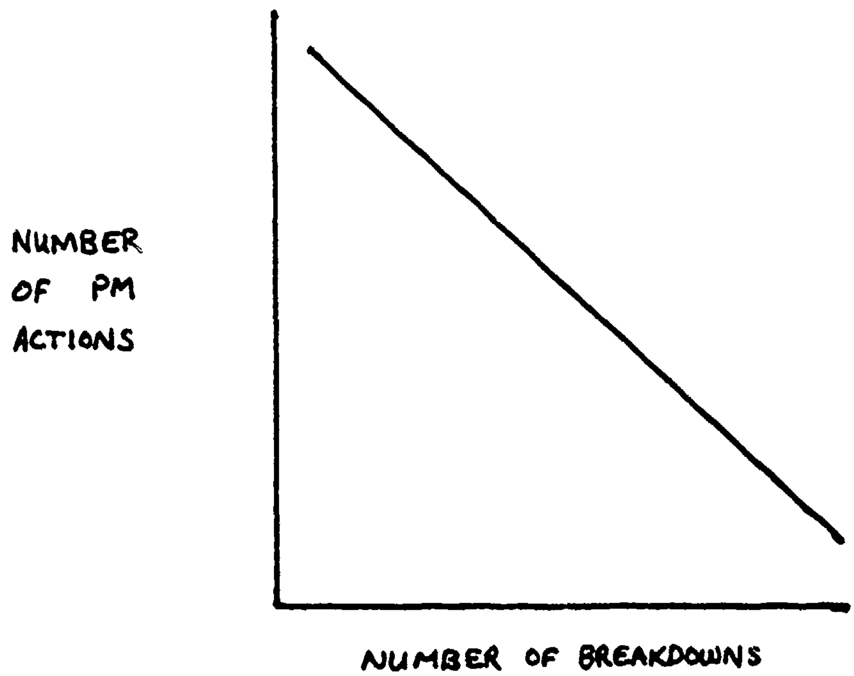


Figure 2-5. Effect of PM Actions on Breakdowns



two. Periodic PM may be scheduled as a result of the passage of calendar or equipment operation time. Condition based PM requires some method of equipment inspection and/or monitoring. An optimal PM policy minimizes the total cost resulting from both inspections and equipment failures while maximizing equipment availability. The different types of PM policies currently being used are termed preparedness, sequential, periodic and reliability based (McCall, 1965).

Preparedness PM policies are designed for equipment that has been placed in storage to be used in an emergency. As a result, the type of PM program chosen is intended to maintain an acceptable level of equipment readiness. This type of PM policy has little practical value for most facility maintenance managers and will not be discussed further.

The second type of PM policy in use is the sequential PM policy. As it is primarily concerned with equipment undergoing rapid technological changes, this policy is more concerned with equipment replacement than equipment maintenance. It, too, has little application for most facility maintenance managers.

The most familiar and widely used maintenance strategy is the periodic PM policy. Equipment is inspected on a predetermined periodic basis and repaired when defects are noted. Little, if any, thought is given to equipment replacement under this policy. Breakdowns are frequently

very disruptive and are generally responded to in a crisis management style. The most salient feature of periodic PM is its ease of being understood by all who have to work with it.

Unfortunately many PM inspections performed in periodic PM systems are invalid, unnecessary and redundant. Because the PM workload is often given a low priority and frequently overwhelms the manpower resources of a maintenance staff, scheduled inspections frequently are not done, and/or the actions that are taken involve hurried and faulty workmanship (U.S. National Bureau of Standards, 1982). In such cases the PM program is almost worse for the equipment than no program at all.

The newest PM policy being practiced is that of reliability centered maintenance (RCM). First successfully used by United Airlines beginning in 1965 for aircraft maintenance, RCM has recently crossed over into facility plant maintenance. RCM assigns maintenance tasks which are directly related to equipment failure modes, the risk of failures, and their consequences. Five steps involved in one RCM process for physical plants are: 1)Information Collection--plant design, maintenance history, operating procedures, etc.; 2)Identification and Partitioning--a breakdown of the plant into subsystems; 3)Requirements Analysis--a breakdown of significant subsystems in terms of failure modes, failure consequences, failure history, built-in redundancies, etc.; 4)Preventive Maintenance Task

Selection--type and frequency of PM, and/or repair or replace recommendations, and/or recommended plant design changes; and 5)Packaging--an assembly of a complete maintenance plan (Smith and Matteson, 1985). Although this paper deals with facilities other than physical plants, many of the concepts of RCM can and will be applied to general facility equipment maintenance in subsequent chapters.

CHAPTER 3 DESCRIPTION OF U.S. NAVAL ACADEMY PM PROGRAM

The Public Works Department of the U.S. Naval Academy is responsible for maintaining facilities with an estimated replacement cost of almost two billion dollars and an annual viewing audience of a few million visitors. Like other Navy activities worldwide, one aspect of the Academy's facilties management effort is its Preventive Maintenance Inspection program. This program is based on a periodic PM policy. In 1983 the Academy scheduled 44,244 manhours of PM and accomplished 38,101 manhours through its Civil Service workforce. PM generally accounts for about 5.5% of the Department's Maintenance Division workload in terms of manhours expended, and the 1983 manhours accomplished translate into an estimated annual cost (1985 dollars) of about a half million dollars (USNA, 1983 and 1985). Table 3-1 is a summary of annual PM inspections broken down by work center or shop. Table 3-2 is a modified version of the Academy's priority matrix for work accomplishment (USNA, 1979). Of eleven prioritized elements, with number one being most critical and number eleven least critical, routine preventive maintenance is ranked a lowly eighth. On a similar scale for Navy-wide facility applications, the relative ranking of routine PM is about the same (U.S. Navy, Nov 1977).

Virtually every piece of dynamic equipment at the Naval Academy is included in the PM program. Scheduling

Table 3-1. Total 1983 Naval Academy PM Inspections

Work Center	Number of Inspections	Minimum Manhours Required*	Avg Time For Single PM Check
04 Machine Shop	10,056	5,374	.53 hrs/job
06 Electric Shop	5,112	3,627	.71 hrs/job
07 Air Cond & Ref	10,964	7,278	.66 hrs/job
08 High Volt Dist	638	1,027	.62 hrs/job
18 Environ Control	1,001	871	.87 hrs/job
19 E/S Perry Center	668	2,292	3.43 hrs/job
TOTAL	28,439	20,469	.72 hrs/job

*No time added for travel, etc.

Table 3-2. Naval Academy Priority Matrix

EMERGENCY OR EXCEPTIONAL TOP PRIORITY: 1

IMPORTANCE LEVEL	WORK CLASSIFICATIONS: SAFETY	FUNCTIONAL	PREVENTIVE	APPEARANCE
HIGH	2	5	5	5
ROUTINE	3	6	8	10
LOW	4	7	9	11

frequency is based primarily on past practices, e.g., pumps are almost always inspected quarterly because that is what has traditionally been done. In their equipment handbooks, most manufacturers leave the PM scheduling up to the user because of the variables associated with environment, loading, use, etc. Other sources of recommended PM frequency have periodicities for different types of equipment which fairly closely resemble those used by the Academy (Grothus, 1976; Sack, 1963; and Seboda, 1978).

Administrative control over the PM program rests with the Public Works Department's Maintenance Control Division. Essentially one person administers the PM program in this division. The Maintenance Control Division is a separate entity from the Maintenance Division. The latter actually performs the PM with some of its approximately three hundred personnel. In fact these two divisions are the prime players in a check and balance arrangement. The Maintenance Control Division does the estimating for the work and schedules it on a monthly basis. The Maintenance Division refines the schedule to meet its daily needs and actually performs the work. As a governmental entity, this separation of functions is necessary because it helps alleviate the possibility of waste and abuse of materials and labor within the department. Variances (materials and labor over/underruns, etc.) associated with a job are identified, investigated and resolved between the two divisions. Another advantage to this organizational

arrangement results from the distinct assignment of job responsibilities. Each person's role is clearly defined and the expectations associated with a role are well understood. From an operational standpoint, however, there is some inefficiency involved in this type of organization. Redundant site visits by various members of both divisions, and the tendency for the estimator and foreman to differ in their approach to a job are two such examples. But generally the system works well.

Another important factor in PM is parts supply. This is an issue which will not be discussed in this thesis because it is not the responsibility of the Public Works Department.

Up until 1984, a month's workload of PM inspections were passed to the Maintenance Division in a hard card form, a sample of which is provided in exhibit 3-1. This card, identical on front and back, provided basic equipment information and listed in numeric format the PM check points that were to be accomplished on a given piece of equipment. These check points are described in Navy publication NAVFAC MO-322, a sample page of which, corresponding to the exhibited hard card, is provided in exhibit 3-2. On the card the mechanic indicated what type of maintenance action he performed. These cards were then returned to the Maintenance Control Division where they were held until the next inspection cycle.

In an effort to administratively refine the PM system,

Exhibit 3-1. PM Hard Card

INSPECTION CHECKOFF RECORD
NOW USING [illegible]

USE INSPECTION GUIDE: PG 72 | WORK CENTER: 04 | CODE: NI Not Inspected; ✓ Satisfactory; Ⓧ Adjustment Required / Adjustment Accomplished; – Not Applicable; XX Repair Required / Repair Accomplished

KEYS — TOOLS
Kirkover Hall

MFR
MODEL NO
SER NO

DATE INSPECTED	SHIFT	CHECK POINTS SCHEDULED FOR INSPECTION	1 / 17 / 33	2 / 18 / 34	3 / 19 / 35	4 / 20 / 36	5 / 21 / 37	6 / 22 / 38	7 / 23 / 39	8 / 24 / 40	9 / 25 / 41	10 / 26 / 42	11 / 27 / 43	12 / 28 / 44	13 / 29 / 45	14 / 30 / 46	15 / 31 / 47	16 / 32 / 48	INSPECTOR'S INITIALS	INSPECTION HOURS STD	INSPECTION HOURS USED	DEFICIENCY REPORT MADE YES	DEFICIENCY REPORT MADE NO
12 [illegible]	M	1-12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					[illegible]	.5	.5		✓
3 [illegible]			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					[illegible]		.5		–
6 [illegible]			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					[illegible]		.5		✓
9 [illegible]			·		·	·	·	·	·	·	·	·	·	·					[illegible]				
1 [illegible]			✓	✓	✓	✓	✓	✓	✓	·	·	✓	·	·					[illegible]		·		✓
[illegible]			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					[illegible]		.5		✓
[illegible]			DOWN FOR REPAIRS TO MOTOR																[illegible]		.2		✓
[illegible]				·	·	·	·		✓	✓	✓		·	·					[illegible]				·
2 [illegible]			✓	·	✓	✓	·	✓	·	·	·	✓	·	✓					[illegible]		·		–

[illegible] 77-590 — [illegible]: Air Compressor 75 HP — LOCATION Ground Floor [illegible]

MAINTENANCE INSPECTION/SERVICE CHECKLIST

MOTOR/PUMP ASSEMBLY

Guide No. ______

Checkpoint	Description
	Safety — Comply with all current safety requirements.
1.	Check for leaks.
2.	Check gauge glass.
3.	Check for leaks around pump packing gland. Repack, replace or tighten as required.
4.	Lubricate pump.
5.	Check oil level in reduction unit. Add oil as required.
6.	Lubricate electric motor where applicable. DO NOT OVER LUBRICATE.
7.	Check relief valves for proper operation and pressure release. Adjust as required.
8.	Check motor for excessive noise or vibration.
9.	Clean filter and strainer.
10.	Check all pipe hangers and supports, tighten if necessary.
11.	Check for rust and corrosion. Remove rust and corrosion and apply paint where applicable.
12.	Inspect wiring and electrical controls for loose connections; charring, broken or wet insulation; evidence of short circuiting, and other deficiencies. Tighten, repair or replace as required.

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Exhibit 3-2. PM Checklist

the PM hard card was replaced with a word processor generated paper sheet in 1984. This sheet, as shown in exhibit 3-3, essentially provides the same information as the PM hard card, but in a slightly less "user friendly" form. The new sheets had three pieces of equipment listed per page and could not be as easily arranged by the mechanic in a logical manner by location as the old cards could. Since new sheets were generated each inspection cycle, they did not provide for a snapshot carryover maintenance history on a piece of equipment as the old cards did. In both the card and sheet systems, if the mechanic identified a discrepancy he could not repair on the spot, it was written up on an inspector's report and sent to the Maintenance Control Division. They then initiated some form of work order depending on the scope of the work involved. Also in both systems, equipment breakdowns were documented using the emergency and service work authorization form depicted in exhibit 3-4.

Currently the Naval Academy is transitioning over to yet another administrative PM system. This one is the result of a recently arrived, Navy issued, mini computer based facility maintenance system known as BEST, an acronym for Base Engineering Support Technical. PM is one of the software modules of the system which includes modules for most Navy Public Works Departments' functions. The Academy is one of the first of many Navy activities to receive BEST. There will be a great deal of work required to input

****

Card No.	Shop W.C.	Building Name	Building Number	Item Description	
740	04	Luce Hall	112	H.water pump,277GPM,15HP,frame 05	
Item Location		**Mfr. Name**		**Serial Number**	**Model Number**
Mecn.Rm.		Taco Inc.		TLO-cont.Model#	3E3C12103C5B2H2
Inspection Guide		**Check Points for Inspection**		**Frequency Required**	**Month Due**
MO-322,Vol.2,pg.72		1-12		Q	Feb May Aug Nov
Date Insp.	**Insp.'s Initials**	**Insp. Hours Std. /Used**		**Deficiency Report Made**	
2-12-85	PC BM	.5	.5	Yes/No	

****

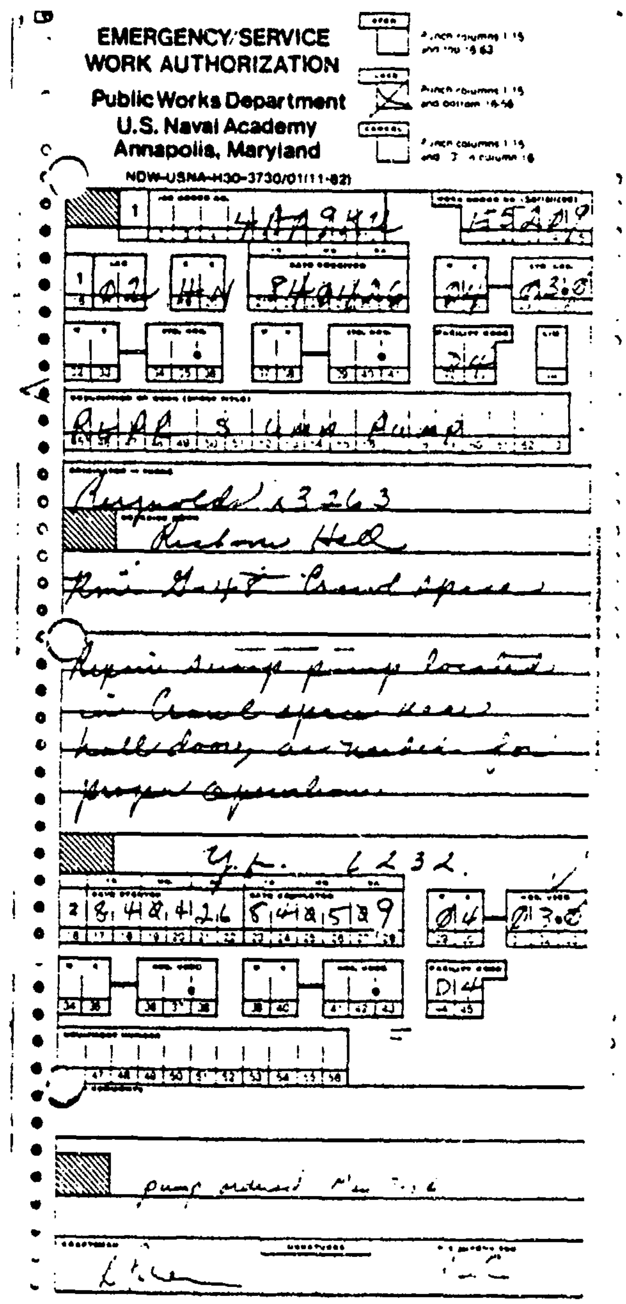
Card No.	Shop W.C.	Building Name	Building Number	Item Description	
741	04	Luce Hall	112	Condensate pump #1, 3-HP	
Item Location		**Mfr. Name**		**Serial Number**	**Model Number**
Mecn.Rm.		Federal Pump Corp.		B50769	CCV-1560-2
Inspection Guide		**Check Points for Inspection**		**Frequency Required**	**Month Due**
MO-322,Vol.2,pg.72		1-12		Q	Feb May Aug Nov
Date Insp.	**Insp.'s Initials**	**Insp. Hours Std. /Used**		**Deficiency Report Made**	
2-12-85	PC BM	.5	.5	Yes/No	

****

Card No.	Shop W.C.	Building Name	Building Number	Item Description	
742	04	Luce Hall	112	Condensate pump #2, 3-HP	
Item Location		**Mfr. Name**		**Serial Number**	**Model Number**
Mech.Rm.		Federal Pump Corp.			CCB-1560-2
Inspection Guide		**Check Points for Inspection**		**Frequency Required**	**Month Due**
MO-322,Vol.2,pg.72		1-12		Q	Feb May Aug Nov
Date Insp.	**Insp.'s Initials**	**Insp. Hours Std. /Used**		**Deficiency Report Made**	
2-12-85	PC BM	.5	.5	Yes/No	

****

Exhibit 3-3. PM Paper Sheet



EMERGENCY/SERVICE
WORK AUTHORIZATION

Public Works Department
U.S. Naval Academy
Annapolis, Maryland

NDW-USNA-H30-3730/01(11-82)

Exhibit 3-4. Emergency/Service Work Authorization

the equipment inventory into the system's database and then identify the appropriate check points for each piece of equipment. A sample copy of the BEST PM workorder provided to the mechanic is shown in exhibit 3-5.

Organizationally the actual PM workload is apportioned among the appropriate Maintenance Division trade specific shops which are staffed with mechanics from the various construction trades. Each shop foreman is responsible for carrying out his assigned month's PM workload. Prior to 1982, there was a single designated PM Shop consisting of about twenty mechanics from various trades. This shop had the responsibility for performing almost all of the Academy's PM functions. Management decided to disband the PM Shop and disperse the mechanics to the trade specific shops in hopes of leveling out the manpower resource requirements in the trade specific shops. Within the Maintenance Division there exists two multi-trade emergency/service shops designed to fix those broken items which require less than sixteen manhours to repair. There is no easy way to compare their repair records with the other shops' PM records in any of the three PM systems or the two PM organizations the Academy has recently used. It is also difficult to obtain accurate cost data associated with the PM program. Consequently little analysis of the program was ever done at any level of Academy management.

DATE PRINTED: [illegible] PAGE: [illegible]

** PM WORK ORDER **

WORK ORDER NO: [illegible] [illegible] CONTROL NO: [illegible]

JOB ORDER NO: SCHEDULED DATE (WEEK OF): [illegible]

[illegible] NUMBER OF UNITS: [illegible] STD HRS: [illegible]

** INSPECTOR REMARKS **

DATE COMPLETED (YYMMDD): ______________ ACTUAL COMPLETED HOURS: ________

INSPECTOR SIGNATURE: ____________________________________

** PHASE DESCRIPTION **

2 CLEAN [illegible]
3 TEST SAFETY VALVES
4 CHECK OIL LEVEL IN CRANK CASE-ADD OIL AS REQUIRED
5 DRAIN CONDENSATE FROM TANK
6 INSPECT BELT-ADJUST OR REPLACE IF NECESSARY
7 CHECK MOTOR FOR HEAT AND VIBRATION
8 LUBRICATE MOTOR AS APPLICABLE

** CHECKPOINTS **

OP NO.	TYPE	DESCRIPTION	HOURS	OCCURS	TOTAL
[illegible]	1	GAIN ACCESS TO MACHINE ROOM	[illegible]	2	[illegible]
25102	1	OPEN AND CLOSE LATCH TYPE LID OR COVER PLATE	[illegible]	2	0.0[illegible]
25103	1	CHECK COMPRESSOR OIL LEVEL. ADD OIL AS NECESSARY	[illegible]	2	[illegible]
25104	1	CHECK TENSION, CONDITION AND ALIGNMENT OF V-BELT ON FRACTIONAL HP COMPRESSOR. ADJUST AS NECESSARY	0.029	2	0.0[illegible]
25105	1	REPLACE V-BELT ON FRACTIONAL HP COMPRESSOR (ONE BELT)	0.247	2	0.49[illegible]
25106	1	CHECK TENSION AND CONDITION OF V-BELTS ON LARGE COMPRESSOR. ADJUST AS NECESSARY (AVG. THREE BELTS)	0.087	2	0.17[illegible]
25107	1	REPLACE V-BELTS ON LARGE COMPRESSOR (AVG. THREE BELTS)	[illegible]	2	[illegible]
[illegible]	1	DRAIN MOISTURE FROM AIR STORAGE TANK AND CHECK [illegible] PRESSURE CUT-IN [illegible] DRAINING. CHECK DISCHARGE FOR INDICATION OF INTERIOR CORROSION	[illegible]	2	[illegible]
[illegible]	[illegible]	[illegible] COMPRESSOR	[illegible]	[illegible]	[illegible]

Exhibit 3-5. BEST PM Work Order (Page 1)

```
DATE PRINTED: [illegible]                                          PAGE: [illegible]
                        *** PMI WORK ORDER ***

WORK ORDER NO: [illegible]                           PM CONTROL NO: 123
DUE [illegible]                  SCHEDULED DATE (WEEK [illegible]
FREQUENCY: M                     NUMBER OF UNITS:  2             STD HRS: [illegible]

                          ** CHECKPOINTS **

CP NO.  DESCRIPTION                                          HOURS/        TOTAL
   TYPE                                                            OCCURS

[illegible] CLEAN REUSABLE OIL FILTER                       [illegible]  2  [illegible]
[illegible] CHECK OPERATION OF PRESSURE RELIEF VALVE        [illegible]  2  [illegible]
[illegible] CLEAN CYLINDER COOLING FINS AND AIR COOLER ON   [illegible]  2  [illegible]
            COMPRESSOR (BRUSH DUST OFF)
[illegible] CHECK FOUNDATION, CYLINDER HEAD, BELT GUARD,    [illegible]  2  [illegible]
            [illegible], ETC. FOR TIGHTNESS, SECURE AS NECESSARY
[illegible] CHECK ELECTRIC MOTOR OPERATION AND LUBRICATE.   0.246        2  [illegible]
            CHECK FOR EXCESSIVE HEAT, VIBRATION, BEARING
            [illegible], ETC.
25115 [illegible] CHECK COMPRESSOR POWER AND CONTROL CIRCUITS AND  0.[illegible]  2  [illegible]
            TIGHTEN ELECTRICAL CONNECTIONS
25116 [illegible] PERFORM OPERATIONAL CHECK OF AIR COMPRESSOR AND  0.173  2  0.34[illegible]
            ADJUST AS REQUIRED
25117 [illegible] CHECK FRACTIONAL HORSE POWER AIR COMPRESSOR FOR  0.367  2  0.7[illegible]
            [illegible] SPRINKLER SYSTEM (INCLUDES CHECK [illegible]
            OIL LEVEL, LUBRICATION AND CONDENSATE DRAIN)
[illegible] CLEAN UP AREA [illegible]                       [illegible]  2  [illegible]
25119 [illegible] FILL OUT MAINTENANCE RECORD/REPORT        0.[illegible]  2  [illegible]
                          ** EQUIPMENT **

NUMBER      NAME                          CODE  FACILITY  ROOM/AREA  ZONE [illegible]
PRIORITY  USER FIELD 1                    USER FIELD 2

46NSC1      COMPRESSOR AIR                 111   46NS      BOILER RM  05   M47
2           [illegible] COMPRESSORS        ENLISTED BARRACKS
                                           * NAMEPLATE DATA *

      BLANK

46NSC2      COMPRESSOR AIR                 111   46NS      BOILER RM  05   M47
2                                          ENLISTED BARRACKS
                                           * NAMEPLATE DATA *

      BLANK
```

Exhibit 3-5. BEST PM Work Order (Page 2)

CHAPTER 4 ANALYSIS OF THE U.S. NAVAL ACADEMY'S PM PROGRAM

Typical of most maintenance organizations, the Naval Academy has not devoted a great amount of management analysis effort to the PM program. Things have organizationally and administratively changed over the past few years as has been noted, but the consequences of the PM program on the equipment have not been studied. This chapter will deal with the issue of the relative success of the Academy's PM program based on historic data.

4.1 Information Gathering

The Naval Academy is often considered to be a unique Navy activity in that it has the reputation for being more than adequately funded because it is, in many ways, the Navy's showplace. Although this impression is true to a degree in some areas, equipment preventive maintenance does not share in the limelight. In addition there are many facilities that the Public Works Department maintains which closely resemble facilties at a "typical" Navy base. Five facilities of this type comprising a cross section of age, mechanical system complexity, and purpose were selected for study, as well as one relatively new academic building which contains a multitude of mechanical systems requiring PM. These buildings are described in tabular form in table 4-1. Since mechanical equipment accounts for the vast majority of the PM workload, only that area of PM will be investigated. Newer and extensively rehabilitated

Table 4-1. Selected Facilities by Age

Building Number	Year Built	1979 Age	Size (SF)	Pieces of Mechanical Equipment	Building Use
590	1975	4	300,000	576	Academic building, also contains large mechanical rooms providing academic complex support
579	1970	9	10,000	57	Central Heating Plant, provides high temperature hot water as heat source throughout Academy
571	1966	13	41,000	84	Public Works Department's shops' spaces
89	1952	27	30,000	25	Recreation building, contains gymnasium and theater
58	1942	37	6,200	6	Naval Station administrative offices
46	1941	38	61,000	52	Enlisted personnel barracks and galley

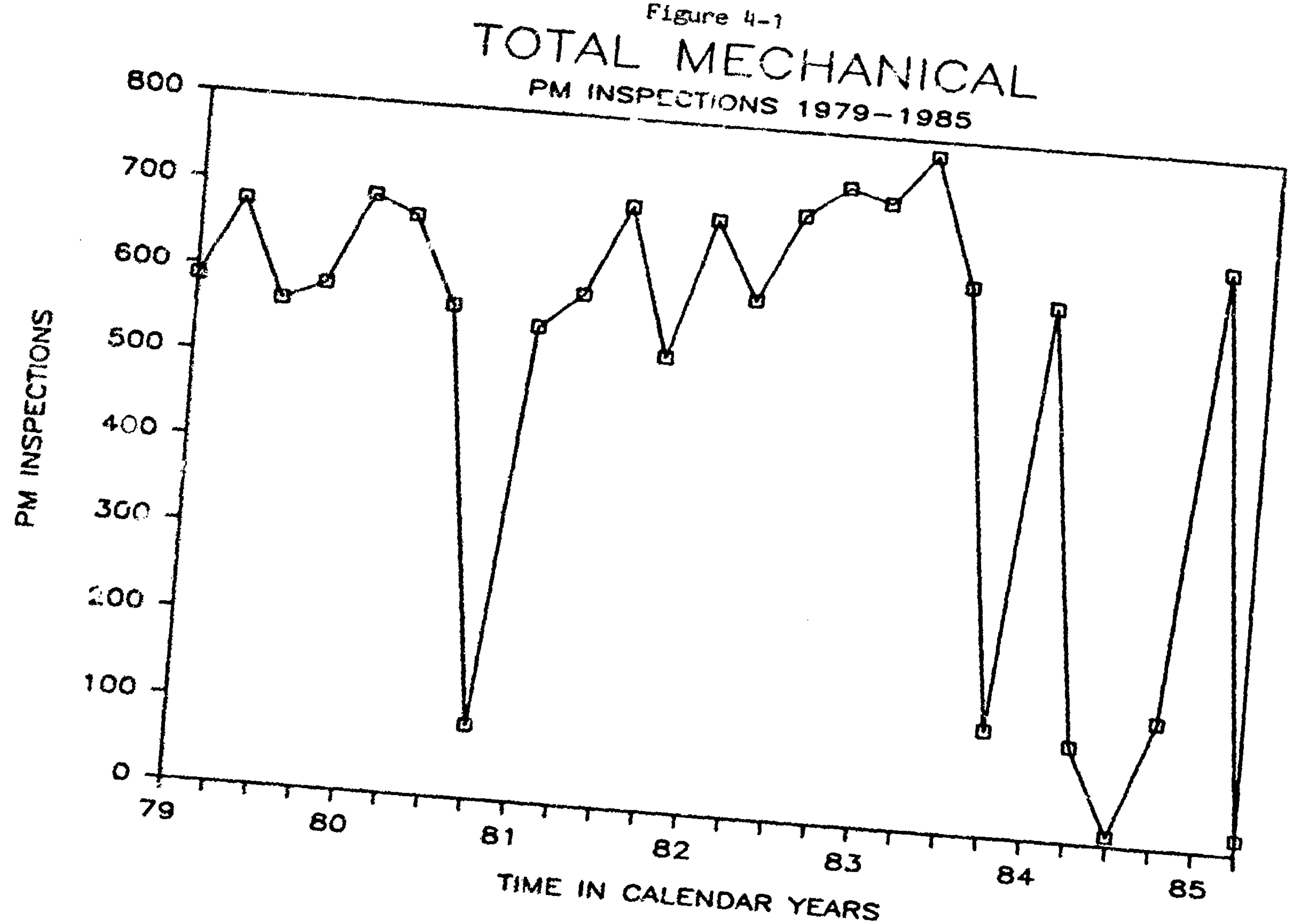
buildings at the Academy characteristically are more mechanically complex, and thus require more maintenance attention than older buildings. This is generally the case of the buildings selected for study, although the building's purpose is also a factor.

Preventive maintenance records, both hard card and paper sheets, were obtained for the mechanical equipment in the selected buildings for the years 1979 through March 1985. A history of mechanical breakdowns were obtained for 1979 through June 1980 and June 1982 through March 1985. Unfortunately the missing two year periods' breakdown records had been disposed of. The raw data gathered is provided in appendix A. Field interviews were held with the division directors of the Maintenance Control and Maintenance Divisions, as well as the PM program administrator, shop foremen and PM mechanics. A visit to each of the buildings being studied and an inspection of their mechanical equipment was also conducted. Data accuracy was assumed to be good, although a minor problem is created by the different expertise and motivational levels of the mechanics involved in the program. But because mechanics were frequently rotated within the program, this effect was assumed to be negligible.

4.2 Data Analysis

Figures 4-1, 4-2 and 4-3 graphically show the numbers of PM inspections, PM actions and equipment breakdowns, respectively, that were experienced between 1979 and March

Figure 4-1



TOTAL MECHANICAL
PM INSPECTIONS 1979–1985
800
700
600
500
400
300
200
100
0
PM INSPECTIONS
79
80
81
82
83
84
85
TIME IN CALENDAR YEARS

Figure 4-2

TOTAL MECHANICAL

PM ACTIONS 1979–1985

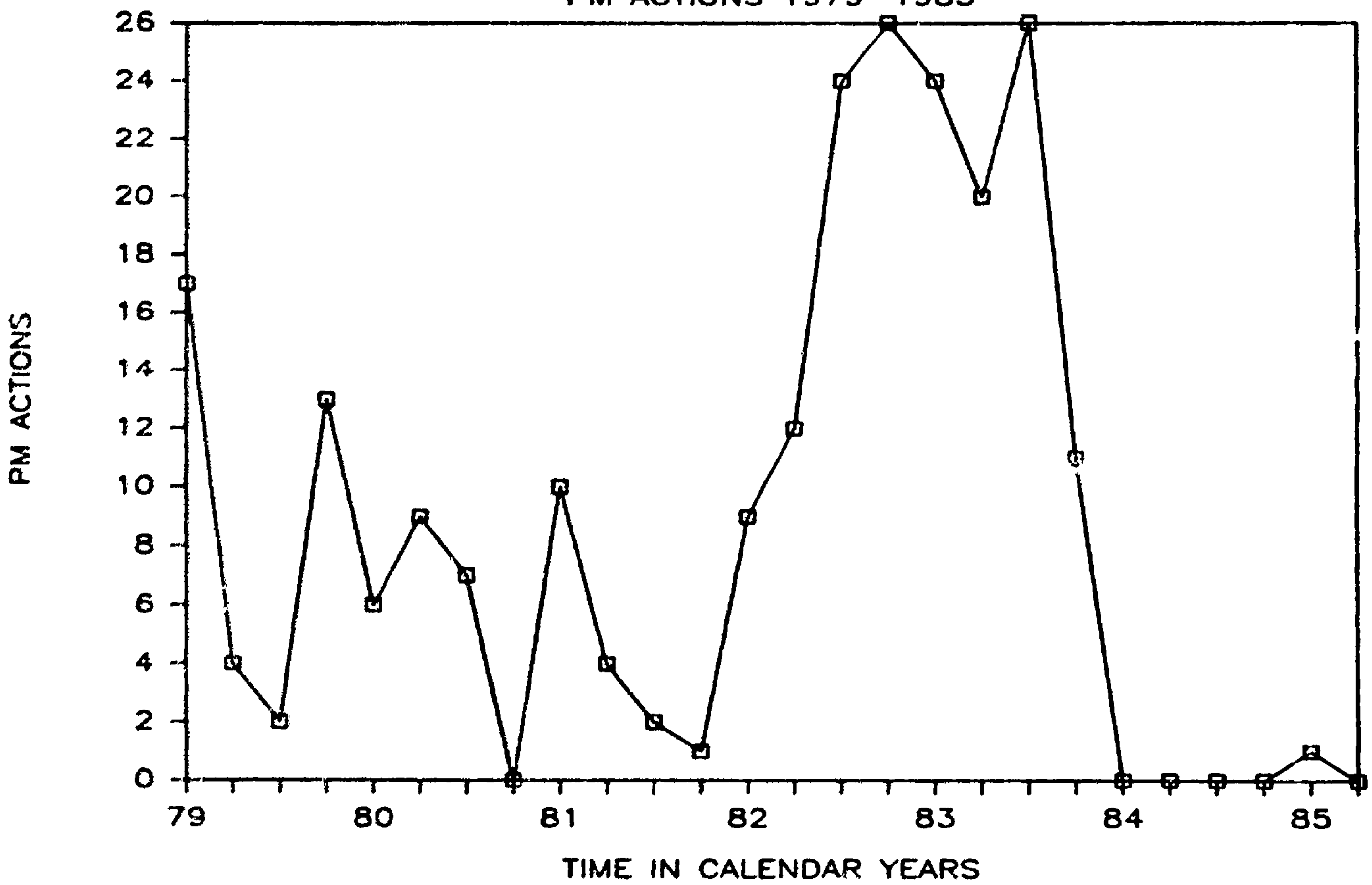
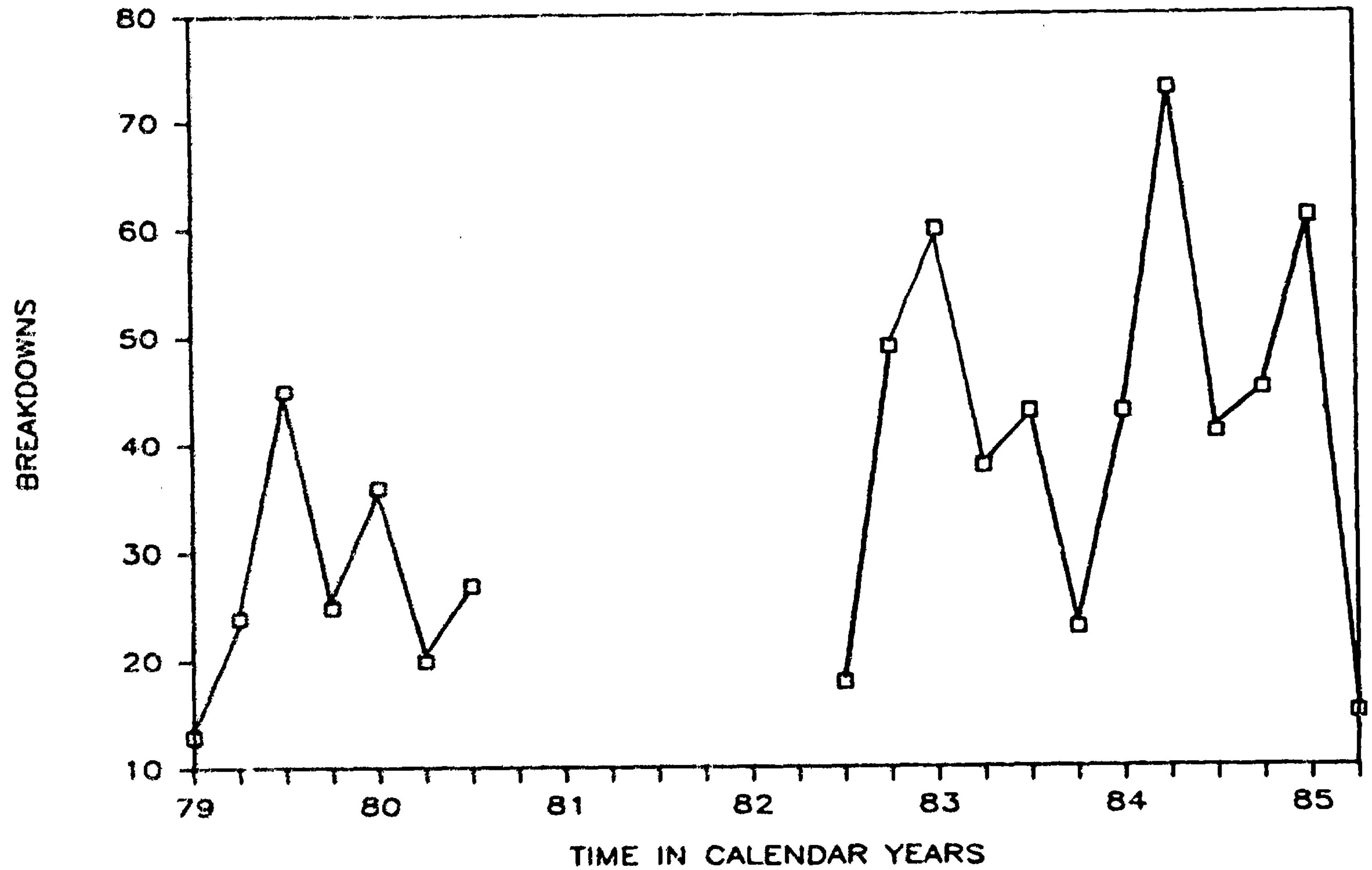


Figure 4-3

TOTAL MECHANICAL

BREAKDOWNS 1979–1985



1985. PM inspections remained at a fairly constant level under the hard card system through the organizational change in 1982, continuing on into 1983. The paper sheet system, implemented in 1984, has been a disaster in terms of the numbers of PM inspections being done each quarter, even though the number scheduled for accomplishment has not changed. One major reason for the drop off is the cumbersome and fragile form of the sheets themselves. Many mechanics each month literally try to cut and paste the new sheets together so they can be put into a more logical geographic or equipment related sequence. Notes such as "pump closest to the wall" and "motor warm, check carefully," which were on the hard cards, are lost from inspection to inspection because new sheets are generated for each inspection cycle. Rescheduling of non-completed PM usually occurs, but the PM is not always accomplished due to the number of PM inspections scheduled each month.

PM actions increased significantly when responsibility for PM was assigned to the trade specific shops in 1982. They were maintained at a relatively high level until the paper sheet system was implemented. Because there is no place on the sheet to document any repair action taken during an inspection, virtually none was documented. Consequently this important piece of equipment maintenance history was lost.

Some argument could be given to the fact that the new paper sheet system was experiencing the effects of a

learning curve during its initial implementation. Unfortunately the system's faults seem to be much more serious and lasting than that. The administrative burden of the sheet system is hard on the mechanics as well as the PM program administrator. The cards, complete with their snapshot of PM history, were durable and relatively easily arranged and filed in a visible file index. The sheets are unwieldy and are typically placed in cardboard boxes after a cursory review.

The number of breakdowns during the period displayed a general rising trend, probably due to the increasing age of the buildings studied. More analysis will be done on the subject of breakdowns on a building by building basis, and also by studying the patterns of breakdowns over the spectrum of all of the buildings' ages. Overall anywhere from about two to nine percent of the equipment broke down in a given quarter.

Three important relationships were examined for each building on a quarterly basis. They are 1)the number of breakdowns versus building age, 2)the number of PM inspections versus the number of breakdowns, and 3)the number of PM actions versus the number of breakdowns. Linear regression analyses using the method of least squares were performed. The mathematical results of the analyses are provided in table 4-2, while a discussion of the results follows below.

In general the coeffecients of determination and

Table 4-2. Linear Regression Analysis Results

Building (New to Old)	Relationship	Data Points	Coefficient of Determination (r^2)	Correlation Coefficient (r)	Standard Error Estimate
BREAKDOWN VS BUILDING AGE					
590	$y = 4.99 + 2.892x$	19	.2064	.4543	12.75
579	$y = 2.80 + .033x$	19	.0005	.0222	3.35
571	$y = -2.91 + .342x$	19	.0797	.2823	2.61
89	$y = -3.70 + .139x$	19	.0887	.2978	1.00
58	$y = -9.54 + .238x$	12	.1028	.3206	.66
46	$y = 5.837 - .065x$	19	.0032	.0566	2.57
Yrs 4-10.5	$y = .014 + .004x$	26	.0708	.2660	.03
Yrs 12½-19½	$y = .074 - .0002x$	31	.0089	.0947	.05
Yrs 27-44½	$y = -.0996 + .0038x$	57	.0976	.3123	.06
Total	$y = .0394 + .0001x$	107	.0008	.0291	.06
PM INSPECTIONS VS BREAKDOWNS					
590	$y = 421.7 - .863x$	19	.0028	.0529	233.09
579	$y = 39.09 + .003x$	19	.0000	.0008	12.82
571	$y = 36.41 - .741x$	19	.0020	.0460	43.94
89	$y = 8.86 - .233x$	19	.0017	.0420	5.87
58	$y = 1.73 - .949x$	12	.1661	.4076	1.49
46	$y = 13.85 + 1.93x$	19	.1065	.3264	14.38
Total	$y = 2.765 - 3.5x$	21	.1569	.3961	.80
PM ACTIONS VS BREAKDOWNS					
590	$y = 8.75 - .089x$	19	.0269	.1639	7.62
579	$y = 1.54 - .184x$	19	.1256	.3544	1.62
571	$y = 2.57 - .004x$	19	.0000	.0026	3.90
89	$y = .067 - .028x$	19	.0156	.1250	.23
58	$y = 0$				
46	$y = 0$				
Total	$y = 6.69 - .107x$	21	.0188	.1373	.08

correlation coefficients for each of the relationships by building were fairly low. What was significant, however, were the trends exhibited by almost all of the relationships when compared on a building by building basis. For example, figure 4-4 shows Building 590's graph of the number of breakdowns versus the building's age, with the plot of the linear regression analysis relationship included. The result shows the tendency of the equipment failure rate to increase over the building's age span of from four to ten years. Similar outcomes were produced by most of the buildings when this relationship was studied. The only exception was Building 46 which showed a slight declining trend in breakdowns during its thirty-eight to forty-four year old time span.

Because there was not enough data available on any one building to study it over its entire life, data for all the buildings' mechanical equipment breakdowns on a per piece of equipment unit basis were plotted relative to the age of the facility. This is shown in figure 4-5. Virtually without exception, the mechanical equipment in these buildings is originally installed equipment. Consequently the plot provides a good estimate of the failure rate of mechanical equipment over time. Three distinct timeframes of building age are present and were individually analyzed. They are 4-10.5 years old, 12.5-19.25 years old, and 27-44.25 years old. The results of the linear regression analysis are provided and compare favorably to what was

Figure 4-4

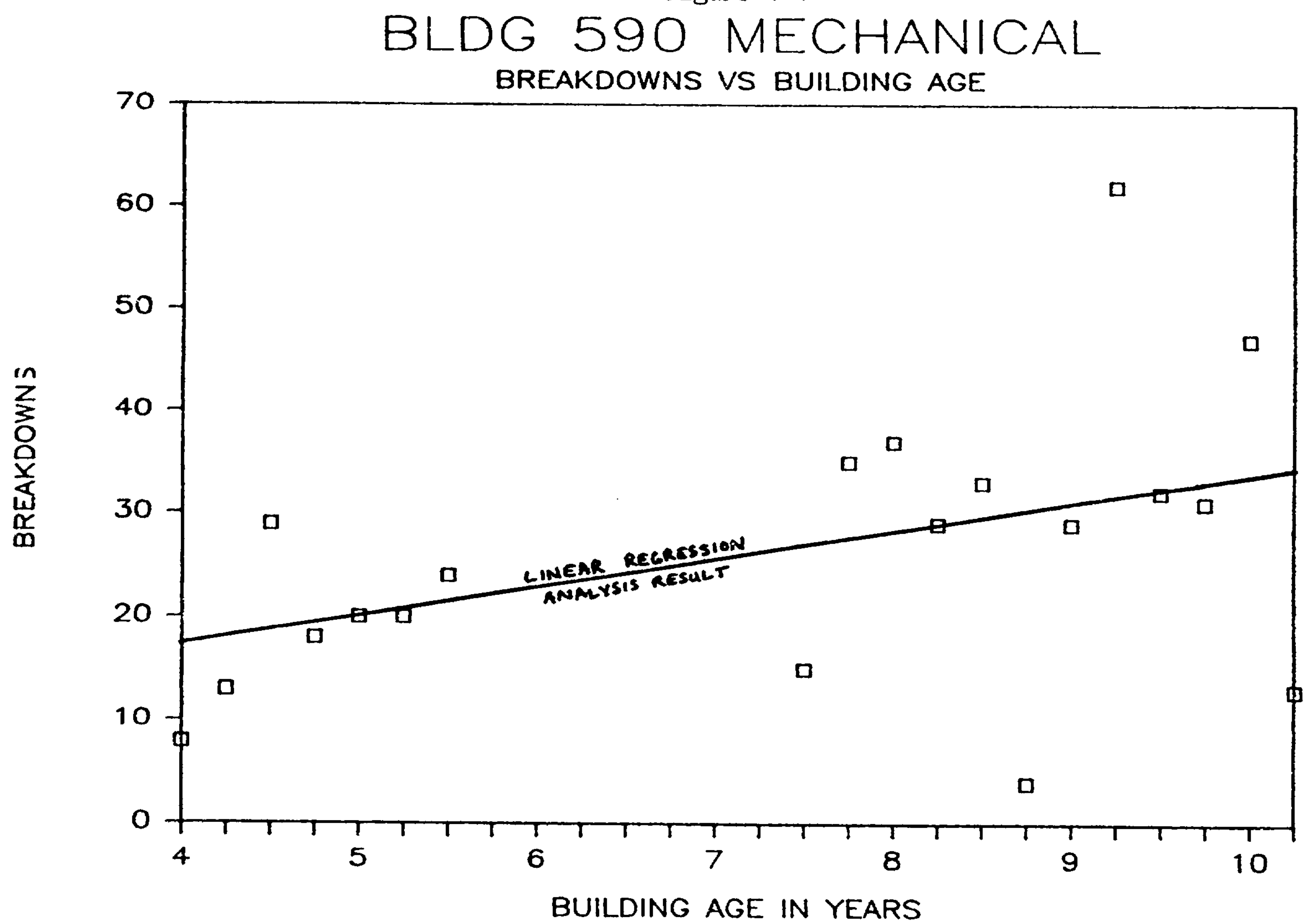
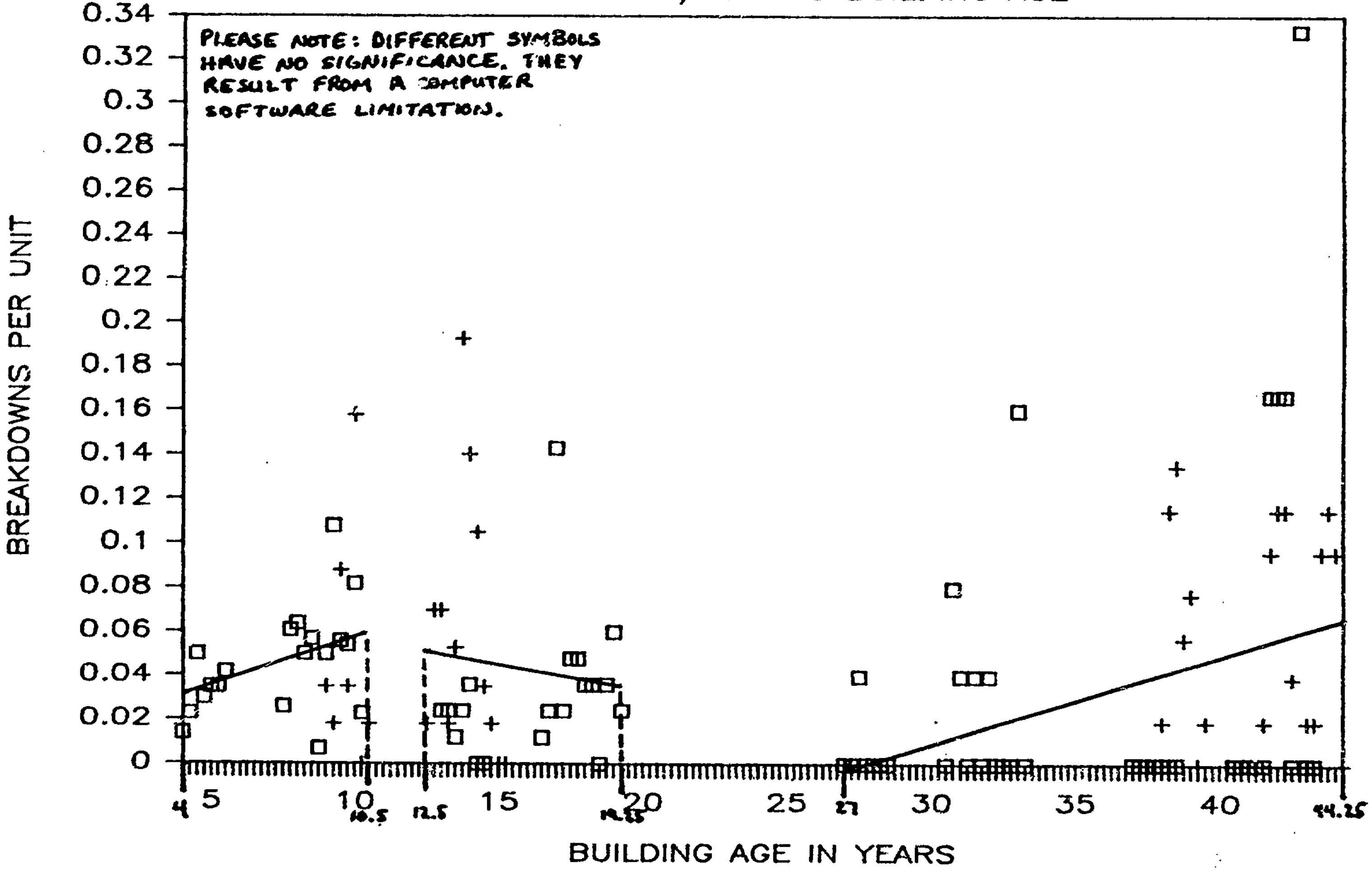

BLDG 590 MECHANICAL
BREAKDOWNS VS BUILDING AGE
70
60
50
40
30
20
10
0
BREAKDOWNS
4
5
6
7
8
9
10
BUILDING AGE IN YEARS
LINEAR REGRESSION
ANALYSIS RESULT

Figure 4-5

TOTAL MECHANICAL

BREAKDOWNS/UNIT VS BUILDING AGE



expected given the Weibull distribution. Equipment early in its life breaks down at a relatively faster rate until the "bugs" are worked out. Then a period of a relatively constant failure rate ensues until the equipment starts to feel the effects of old age when the failure rate increases again.

The next relationship studied was the number of PM inspections per unit versus breakdowns per unit on an annual basis. Figure 4-6 shows the plot of this relationship for all mechanical equipment. The points are identified by the building number and age. This summary plot is consistent with the trends exhibited by the individual buildings. It shows that inspecting the equipment does have a positive effect on equipment performance.

The last relationship subjected to analysis was the number of PM actions per unit versus the number of breakdowns per unit on an annual basis. Here again the individual buildings tended to demonstrate that PM actions had a positive effect on equipment performance, although Buildings 46 and 58 experienced no PM actions over the six year period. The plot of this relationship for all mechanical equipment is provided in figure 4-7. The results of the analysis for this regression are somewhat surprising. One would expect the slope of this relationship to be more pronounced than the slope associated with the relationship between PM inspections and

Figure 4-6

TOTAL MECHANICAL

ANNUAL PM INSPECTIONS VS BREAKDOWNS

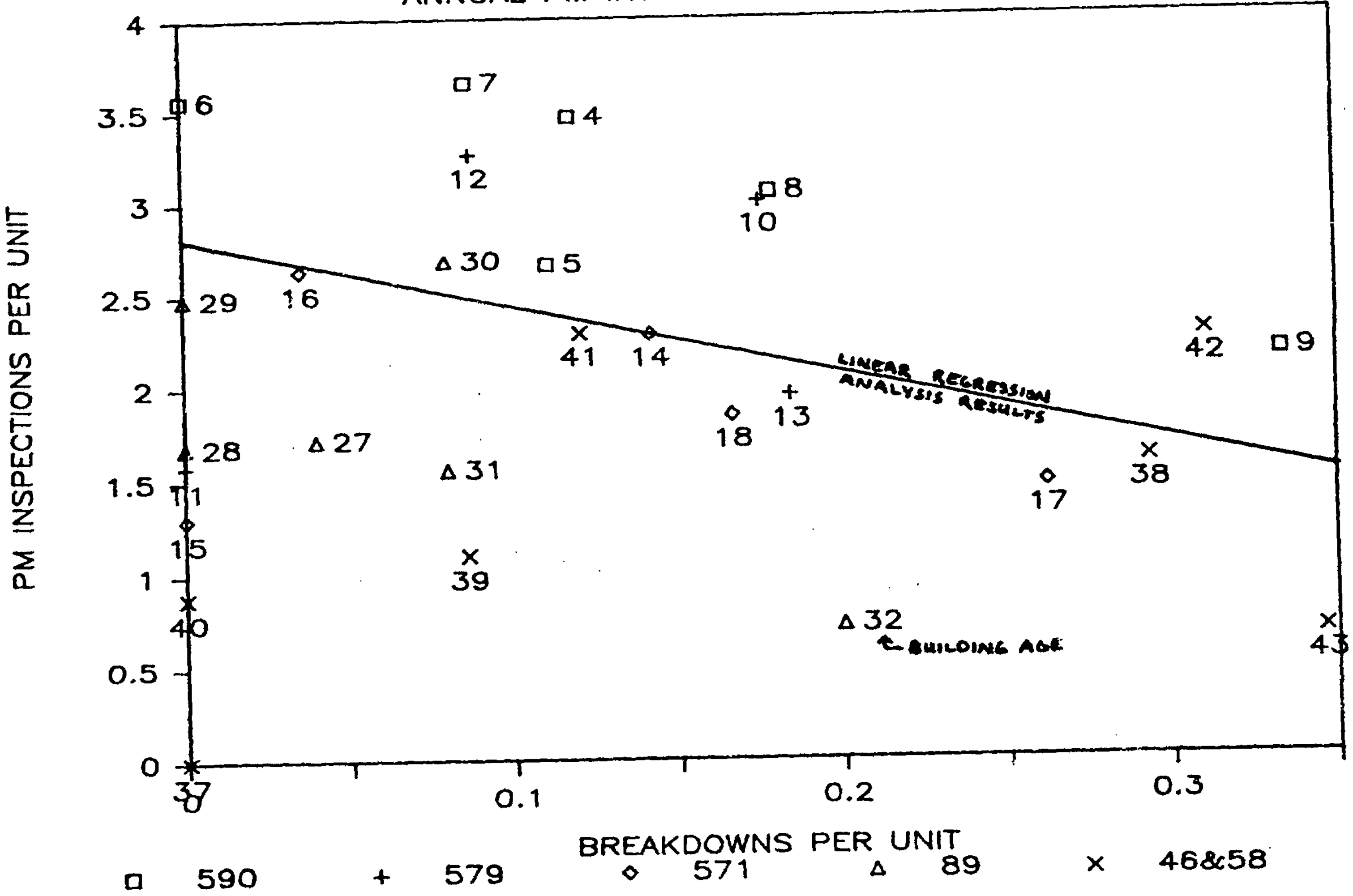
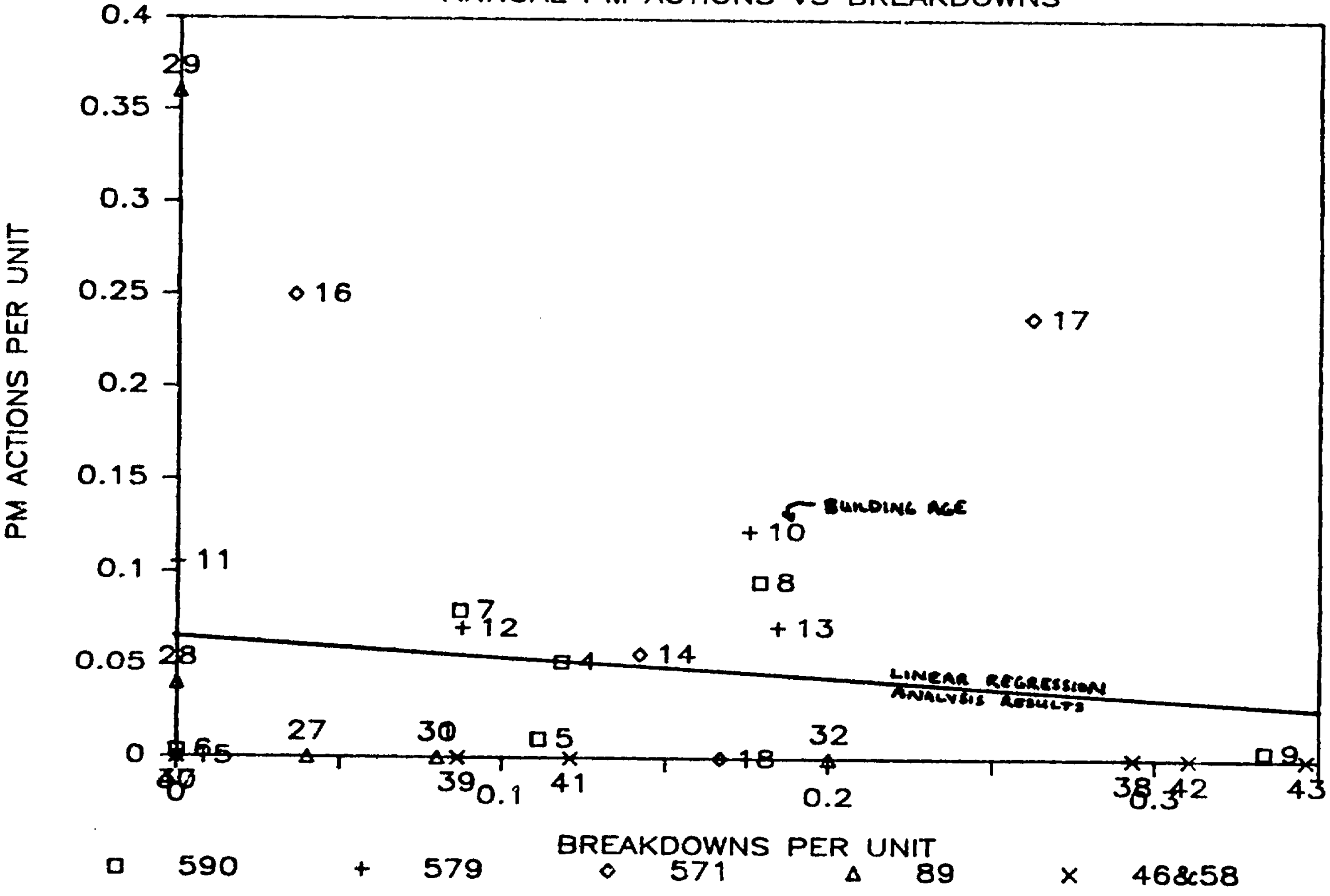


Figure 4-7

TOTAL MECHANICAL

ANNUAL PM ACTIONS VS BREAKDOWNS



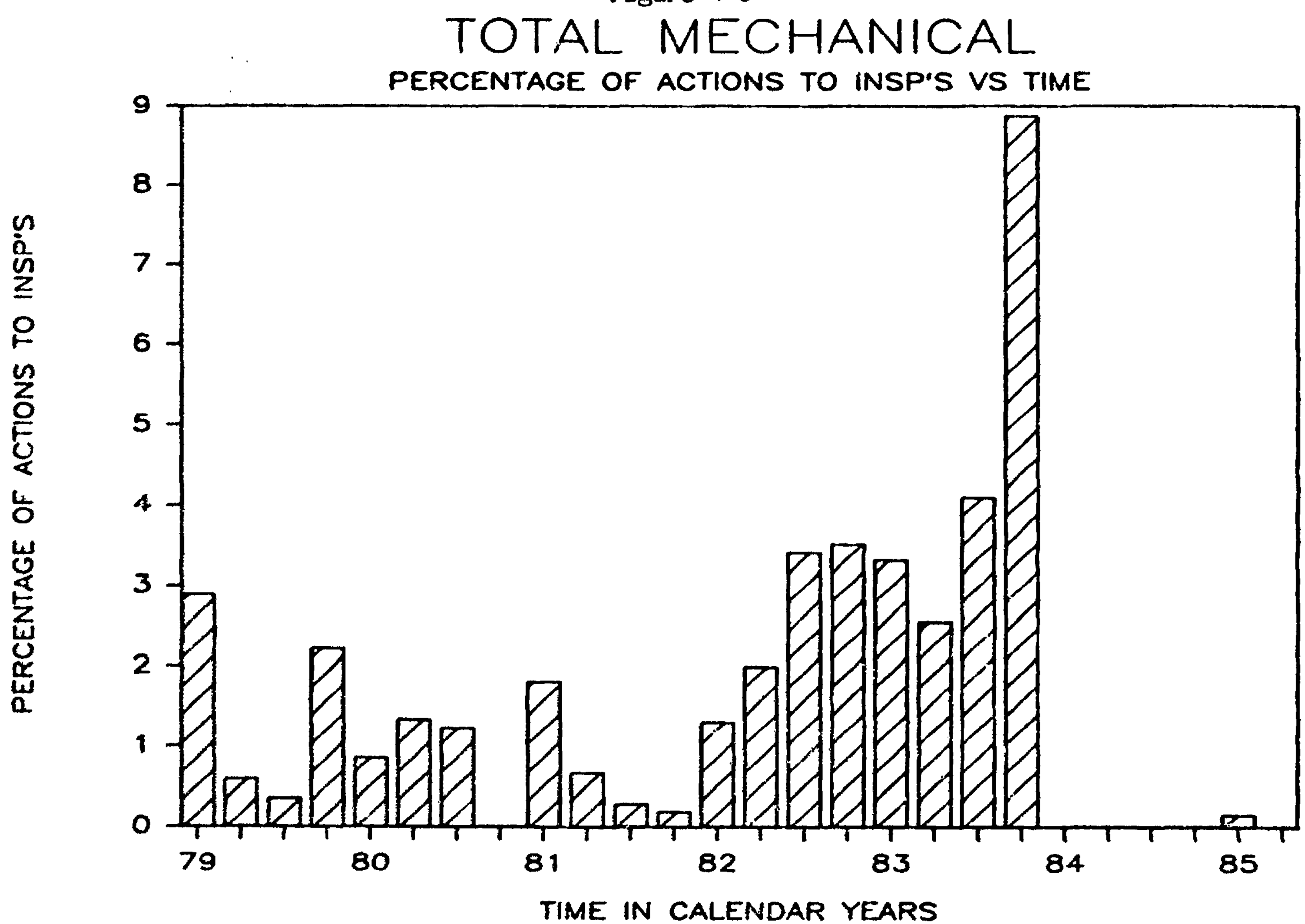
breakdowns. The fact that it is not indicates that PM actions are not quite as beneficial to the equipment as PM inspections are.

In order to study the correlation of PM actions to PM inspections further, the percentage of actions to inspections performed was determined and plotted in figure 4-8. The jump in the final quarter of 1983 is the result of an average number of actions performed, with relatively few inspections completed. This is because the transition to the new paper sheet system was just getting underway. Not including the data for 1984-85 since the sheets did not provide a space to indicate PM actions taken, the average percentage of actions to inspections was 2.18%. Even in the "peak" of PM action accomplishment in 1982-83, the average was only around 3%. So for every one hundred pieces of equipment being visited, only about three were getting extra attention.

4.3 Cost Analysis

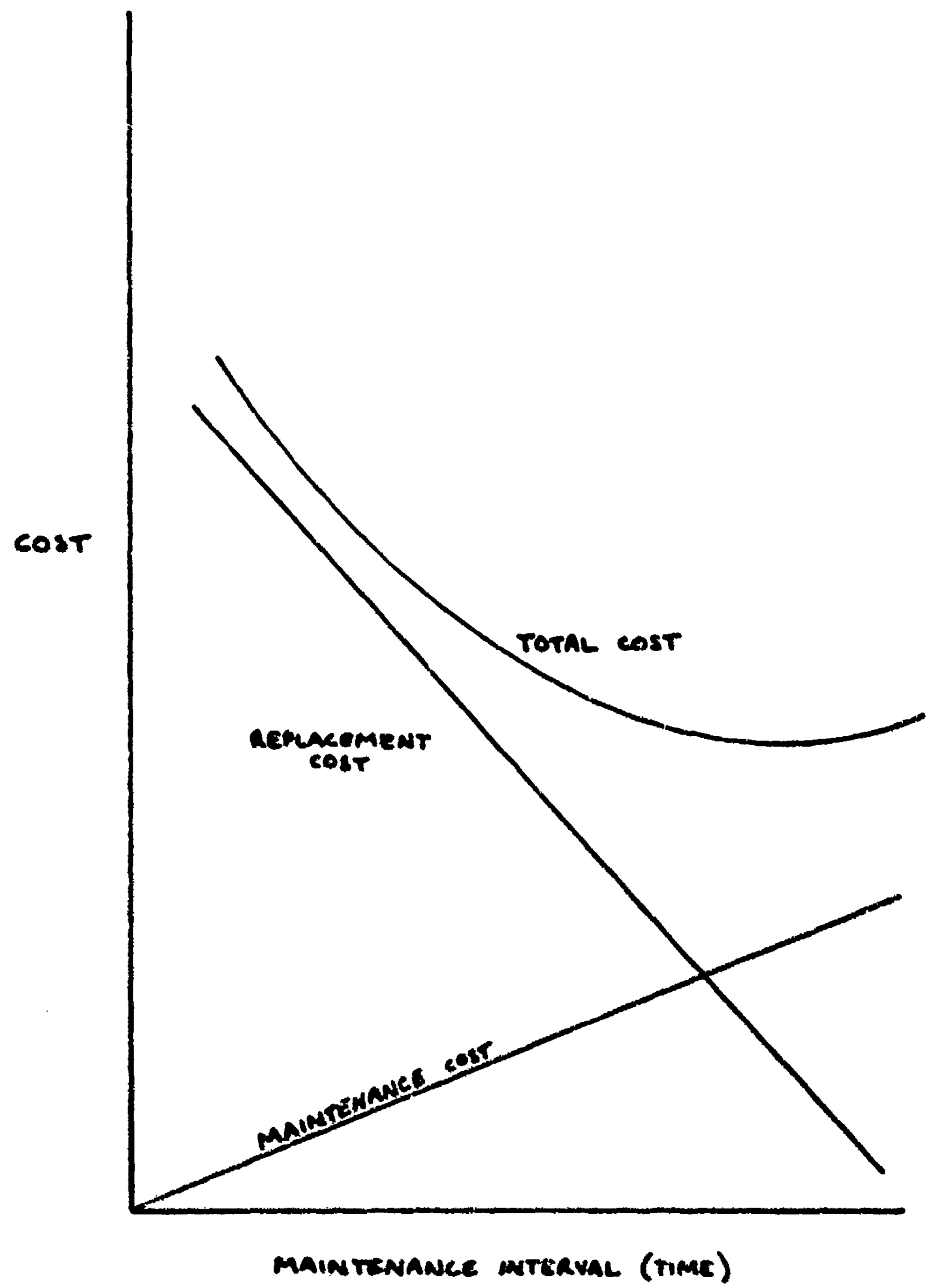
Overall the maintenance data indicates that the Academy's PM program has been a success in positively affecting the mechanical systems' equipment for the better. The next question that arises is, "But at what cost?" Figure 4-9 portrays the trend of the direct costs associated with a PM program. Maintenance costs are incurred every time maintenance is performed. The replacement cost of a piece of equipment decreases over time because of the time value of money (a dollar today is

Figure 4-8



TOTAL MECHANICAL
PERCENTAGE OF ACTIONS TO INSP'S VS TIME
PERCENTAGE OF ACTIONS TO INSP'S
0
1
2
3
4
5
6
7
8
9
79
80
81
82
83
84
85
TIME IN CALENDAR YEARS

Figure 4-9. Direct Costs of a PM Program Over Time



worth more than a dollar tomorrow). One objective of a PM program is to minimize the total life cycle cost. Unfortunately obtaining accurate cost information on the Academy's PM program in any of the recent PM systems is difficult. The method of having job orders cover a variety of buildings and equipment does not allow for cost segregation in a manner that is useful during a comprehensive analysis.

Figure 4-10 shows the costs involved with a $200 piece of equipment over time assuming a five percent annual discount or inflation rate, $15 per hour maintenance rate (labor and minor repairs included), 0.5 manhours spent per quarterly or semiannual inspection, and a forty year equipment life span. The total costs for both inspection frequencies are also plotted. The graph shows that the semiannual inspection policy, as expected, costs much less than the quarterly inspection policy at any given time. Maintenance becomes more expensive than the replacement costs around year nineteen for the quarterly inspection frequency, and year twenty-six for the semiannual inspection policy. Building 590 alone has approximately forty small circulating and sump pumps which cost about $200. If their PM frequency were changed from quarterly to semiannually, an annual savings of $600 and, perhaps more importantly for the Naval Academy, forty manhours of labor would result. Figure 4-11 shows the direct maintenance costs for equipment costing $200, $500, $1000 and $2000;

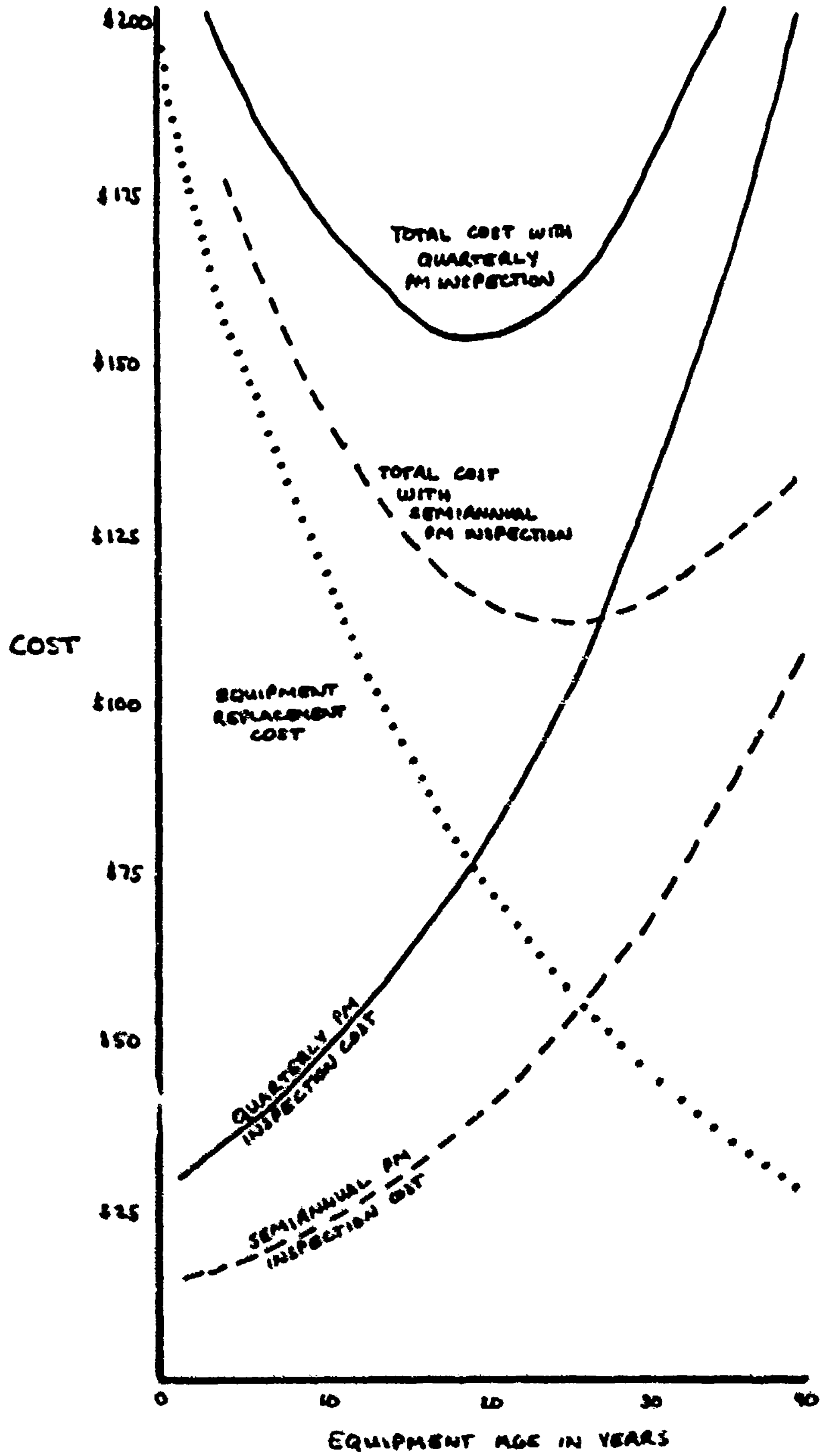


Figure 4-10. Direct Maintenance Costs of a $200 Piece of Equipment

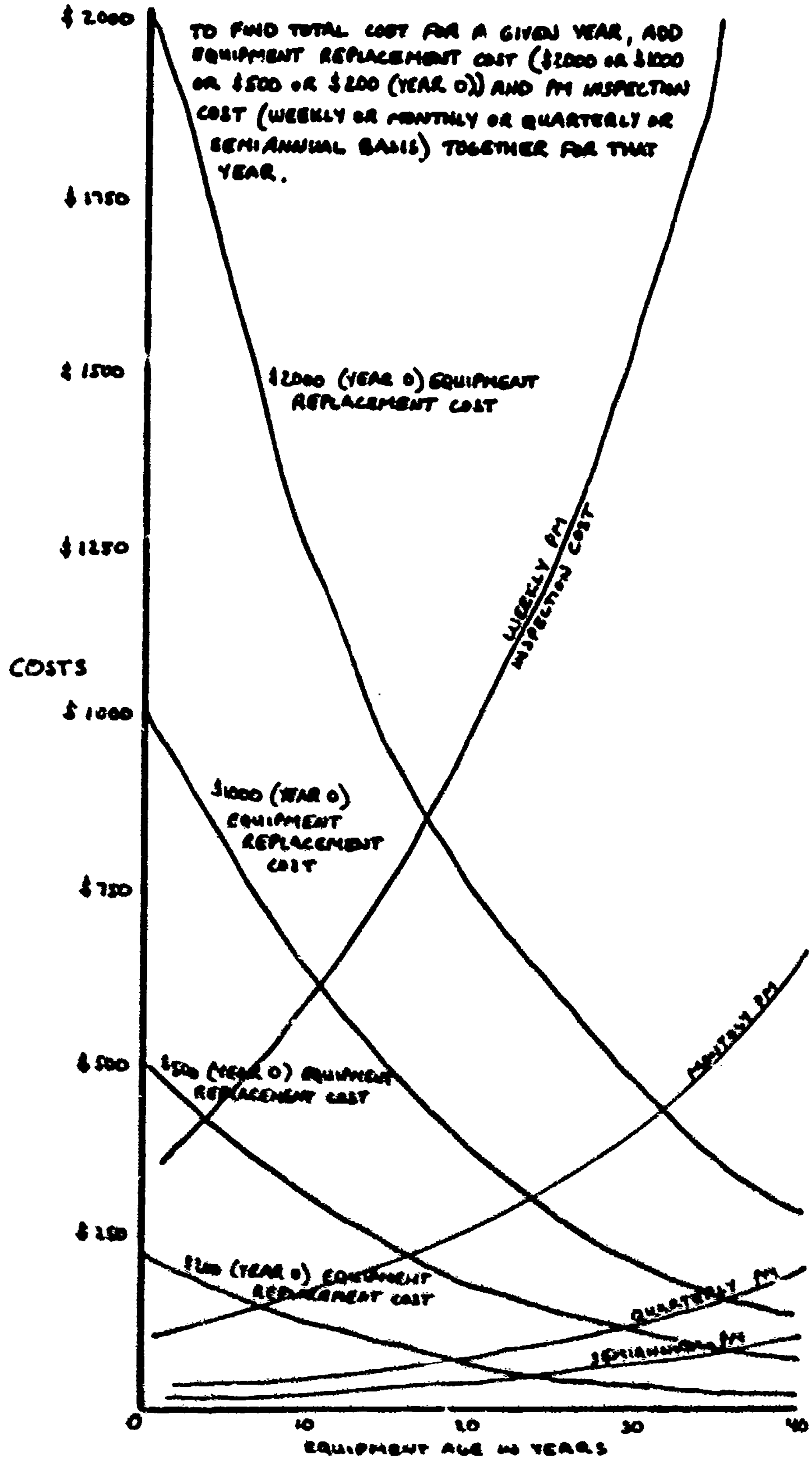


Figure 4-11. Direct Maintenance Cost Comparison Chart

and experiencing weekly, monthly, quarterly and semiannual PM inspections assuming the same conditions as before. It is provided so that other combinations of equipment and PM costs may be investigated by the reader.

As mentioned previously, more than the direct costs must be accounted for in a PM program analysis. There are also indirect costs associated with equipment failure. These may include manufacturing process or office productivity losses from those dependent upon a mechanical system for support or comfort, and physical damage to the failed equipment's surroundings. In Building 590, for example, a failed $200 sump pump may result in millions of dollars in damage to sensitive academic laboratory equipment. The risks involved with the breakdown of equipment can be mitigated through an understanding of the probabilities of equipment failure. Practical applications of the theoretical concepts presented earlier as well as an analysis of the equipments' maintenance history can help establish probability of failure limits. Indirect costs associated with equipment breakdown can then be factored into the total cost equation through adjustment of the indirect costs by the probability of failure. There are also important intangibles which must be considered. The Admiral's window air conditioner better work each time he turns it on, or else!

Other than air compressors which regularly experienced failure, virtually no other individual piece of mechanical

equipment broke down in consecutive quarters, whether PM was performed on a regular basis (pre-1984) or not (since January 1984). In terms of preventive maintenance, only when new belts were installed or ventilation units were adjustments required in consecutive quarters. One parcicularly interesting piece of equipment studied was a ventilation unit in Building 590. That unit never had preventive maintenance performed on it because scaffolding was required for access, but was never provided. It took nine years for that piece of equipment to fail. Consequently it appears that some of the mechanical equipment is being over-maintained, and precious manpower and funding resources are not being efficiently used.

4.4 Management Analysis

All levels of maintenance personnel at the Naval Academy have been voluntarily and not so voluntarily subjected to three different PM systems and two different PM organizations in the last three years. The current paper sheet PM program was a noble effort at trying to streamline some of the administrative burdens of the old hard card system. As noted the new burden has turned out to be at least as bad as the card system was, and now less equipment history is maintained. The Navy designed BEST mini computer system, created and installed in a bureaucratically swift five years, lacks some sophistication and capability in the area of preventive maintenance, especially when compared to today's

technological potential. Except for the added features of automated estimating, written out checkpoints for the mechanic, and spaces for remarks by the PM administrator and mechanic, BEST is very much like the paper sheet system. The same magnitude of paper will be going back and forth between the shops and Maintenance Control, and in all likelihood the completed BEST PM work orders will end up in the PM program administrator's cubicle in a new box right beside the old boxes filled with completed paper sheets. He probably will not have the time to read all of the remarks coming back from the mechanics, much less will he be able to enter all of them into the computer's database. Understandably the PM mechanics will complain about another change in the system and go through another learning cycle. As has happened in the past, the PM mechanic will identify necessary equipment repairs too big for him to fix, and chances are the equipment will not be repaired before his next inspection cycle. After a few instances like this, the PM mechanic will, out of frustration, stop identifying equipment deficiencies. Through it all, hopefully, the equipment will keep on operating.

Any attempt to determine the effects of preventive maintenance will be assisted by BEST only in retrieving breakdown information from the emergency/service module. PM records will have to be manually perused much as they were for this study. At most, if not at all Navy activities, there just are not the resources available to

do the lengthy analysis this sort of investigation requires.

The Academy's PM program and the PM software module in BEST both suffer from a lack of commitment to equipment preventive maintenance. Public Works maintenance resources are understandably reacting to the intense pressure to make things "look better." The more glamorous construction and facility maintenance jobs of larger scope receive the bulk of the maintenance manager's attention, and his management tools reflect this. As with many maintenance organizations in and out of government, the Academy's PM program is an easy area to neglect when faced with competing demands because its effects, both good and bad, are not immediately apparent.

The Naval Academy's maintenance managers have recently, much to their credit, begun aggressively attacking the problems in the preventive maintenance program. One immediately pressing need is to make the issue itself more manageable. There are simply so many PM checks being scheduled each month that they overwhelm those involved with the program. One of the first steps should be to drastically cut back in the inspection frequency requirements. Based on the results of the data analyses, most mechanical PM check frequencies could probably be decreased one level, especially from monthly to quarterly and quarterly to semiannually, without a noticeable loss in equipment reliability. Extremely critical pieces of

equipment, of which there are few, could be left on their current PM schedule. Fewer PM checks, if carried out diligently, would probably result in better equipment performance at a lower cost than the present system provides. One could argue that the current system's frequent maintenance scheduling is the reason for the good equipment performance record. But only about half of the schedule has been completed in the past seven quarters with little, if any, equipment failure increase as a result. Once manageable, refinements of the schedule could be made to determine those pieces of equipment requiring extra attention. Scheduling should also be arranged, as much as possible, so that heating, ventilating and air conditioning systems are checked prior to their period of heaviest use, e.g., unit heaters in early fall and air conditioners in early spring.

One of the problems with the PM program in its present condition is that the PM mechanic who finds a discrepancy in a piece of equipment during an inspection probably is not the person who fixes it. More time, somewhere in the neighborhood of a couple of hours, should be given to the PM mechanic to fix the equipment on the spot when necessary. Inefficiencies arise when planners and estimators are involved simply because another mechanic has to relearn the problem, more forms are required and more trips are taken to the site.

The Academy is essentially required to use the BEST PM

system and should try to use it to its full potential. This will mean the continuation of loading the equipment information into the system's database. Some provision should be made to provide some clerical help to the program administrator so that the remarks off of the completed PM workorders can be both loaded into the database and acted upon by the administrator. In this way some type of equipment maintenance history will be stored and the equipment itself will be better maintained. Training of the PM foremen and mechanics on the BEST system work orders should also be done.

Since the complete implementation of the BEST PM system is still some time away, the Academy should revert back to the old hard card system in the interim. The cards are still available and reasonably up to date and accurate. This will cut down somewhat on the administrative burden of those involved with the program, and restart the equipment maintenance history files. Breakdown history should be looked at quarterly using the BEST emergency/service module to see if there are any pieces of equipment which require extra investigation or attention.

Organizationally the assignment of PM to the trade specific shops seems to have worked reasonably well, although lately the machine shop has had other priorities placed on it causing some of their burden to be shifted to the electric shop. Continuing with this basic organization, the Academy might want to experiment by

considering the permanent assignment of one or two skilled mechanics full-time to a building or set of buildings. These mechanics would be responsible for both the PM program and routine emergency/service repairs in the building. In this way they could become intimately familiar with the equipment, its users and benefactors, and hopefully develop some "pride in ownership" with their sole responsibility. The mechanics would also begin carrying the equipment history database in their heads, rather than having it only on the cards or in the computer. This concept was successfully tested at the Navy Public Works Center in San Diego, California, among other Navy activities, and has become an accepted way of doing business there. Not only has the equipment performance improved at those activities, but so have relations with serviced customers.

CHAPTER 5 A PROPOSAL FOR AN IDEAL PM PROGRAM

As indicated previously, the goals of a preventive maintenance program should be maintenance efficiency, operations efficiency and fiscal efficiency. One of the problems for Navy maintenance managers in achieving these goals is that they are operating under a standardized and accepted preventive maintenance system which is perceived to work, relies almost exclusively on a routinely scheduled PM inspection program, is nearly impossible to analyze and difficult to change. There is relatively new and growing interest, however, in making the Navy's facility maintenance operations more efficient. Part of this is the result of the threatening "A-76" or Commercial Activities program, wherein Navy maintenance activities bid to keep their jobs from private contractors, and part is due to the tone set by the Reagan administration. For example Robert A. Stone, Deputy Assistant Secretary of Defense (Installations), emphasizes "managing for excellence" and has implemented the Model Installations Program whereby certain volunteer Department of Defense activities are able to forego some of the more stifling bureaucratic procedures with the goal of improving overall base efficiency and morale (U.S. Department of Defense, 1985). Building on this spirit, this chapter presents a proposal for an ideal Naval Academy preventive maintenance program and acknowledges some of the barriers standing in the way of

its implementation.

The basic elements of a preventive maintenance program are planning, scheduling, work performance, data collection, equipment history, cost accounting and management information (Newbrough, 1982). Recommendations for the design of a preventive maintenance system will be provided for each of these elements. While it is important to know what makes up a good system, it is also important to realize what adversely affects a PM program. Some of the major causes of ineffective maintenance programs are 1)lack of cost control, 2)lack of good historical equipment records, 3)little or no analysis of equipment failure, 4)poor operator training, 5)supplies mismanagement, 6)inefficient planning, 7)ineffective scheduling, 8)little and/or improper use of non destructive test and diagnostic equipment, and 9)lack of incentive to get and keep good people (U.S. National Bureau of Standards, 1982). These will be considered in the sections that follow.

5.1 Planning

Preventive maintenance planning begins with the design and construction of a building. The types of equipment provided, redundancy characteristics of systems, condition monitoring devices installed, and equipment accessibility are important PM factors which should be taken into account. Studies have shown that the operating and maintenance (O&M) costs of a high rise structure are a whopping forty percent of the total building cost which

includes design, construction, finance, operating and maintenance costs (Ruhlin, 1984). Often only the upfront costs are considered in building design because future O&M costs are discounted too much (Baglow, 1975).

An O&M manual should be part of the building's design package requirements. This "owners manual" could go a long way toward operating the building's systems effectively, training maintenance personnel, establishing maintenance procedures, and creating an accurate equipment inventory (Ruhlin, 1984). The preventive maintenance scheduling portion of the O&M manual should be based not on the standard "cookbook" frequencies found in the literature, but rather on the concepts of reliability centered maintenance.

Most Navy activities currently have buildings which range in age from new to about fifty years old. Some of the items mentioned above obviously do not apply to established buildings. What is required, however, is an accurate inventory of equipment assets.

The next planning step would be to determine what types of management systems and organizational arrangement would best suit the requirements of the PM system. Computerized PM systems have been shown to cut costs almost fifty percent when compared to manual PM systems (Smit, 1983). But that is not a guarantee and it is important to remember that any system must not only work, it must work well and appear to work well. In some instances a

partially manual system may be appropriate. Organizationally each activity should be tailored to meet its own needs. More discussion regarding systems and administration will be forthcoming in following sections.

5.2 Scheduling

The Naval Academy's PM program would greatly benefit from a comprehensive review of its scheduling frequencies if more of the concepts of reliability centered maintenance (RCM) were applied. Although individual Navy activities have some leeway in assigning their PM scheduling frequencies, most follow the tried and true method of scheduling similar equipment on a similar basis, e.g, virtually all pumps at the Naval Academy are inspected quarterly. Little if any consideration is given to a piece of equipment's role as part of a bigger system, the environment in which it operates, its failure modes and consequences in terms of the risks involved, and its maintenance history. No amount of PM will prevent every equipment casualty although the conservative frequency levels recommended in the literature might lead one to believe otherwise. Perhaps the inspection program could be refined to include two different levels of inspection. One level might include the PM inspection as it is now performed, but on a less frequent basis. The other level might be a ten minute walk-through of a mechanical space by a mechanic just cursorily looking and listening for abnormalities during a period when the comprehensive PM is

not performed. In any case these proposals could be fairly easily implemented in six months to a year throughout the Academy if a team of two or so mechanics, who were receptive to and understanding of simple and basic RCM concepts, were also give the time and responsibility for making it happen. The PM program administrator would be deeply involved and there would also have to be some interface with Utilities Division personnel well versed in the Academy's mechanical systems' configurations. This allocation of resources would involve a tremendous initial investment in the amount of manhours spent, but it would probably pay enormous dividends right from the start and completely pay for itself within a few years. The PM system itself could continue to look like it was based on a periodic scheduling philosophy so that the basic administrative structure of the system would not have to be changed.

The RCM team created above would probably develop a list of intuitive rules for determining PM scheduling frequencies during the course of its investigation. These rules could be captured and used in future instances if they were incorporated into an expert system. An expert system is a computer program which is essentially taught to "think" like the expert. If a new piece of equipment were added to the inventory, the expert system would raise the appropriate questions in establishing a PM frequency just as the expert mechanics did. This is probably too

sophisticated a step for one Navy activity to attempt, but it might be something that could be economically and effectively done on a Navy wide basis by a headquarters activity.

5.3 Work Performance

Performing the work in a PM program involves the inspection, maintenance and repair actions necessary to keep the equipment running. Although the mechanic is the most important element in the program, some of the inspection workload could be done by condition monitoring devices placed on the equipment and connected to a status indicating device in a manned space. Satisfactory upper and lower operating limits could be established, and discrepancies could be investigated by a mechanic. Some pieces of the Academy's equipment might be candidates for this feature and they could be monitored in the Michelson Hall energy monitoring control system (EMCS) computer room, or possibly made part of the EMCS itself. Mechanic site inspections of the equipment could be scheduled accordingly. Another aspect of the inspection portion of PM is the method of inspection. Recent strides have been made in diagnostic equipment, particularly in non destructive testing (NDT) equipment, and they should be used where applicable. However, care should be taken in purchasing NDT equipment because some actual performance results do not live up to manufacturers' claims. The cost to benefit aspects of any inspection related device must be

seriously considered at all times.

Within maintenance programs, multi-skilled maintenance workers have been shown to have higher morale and greater job satisfaction than trade specific mechanics (Husband and Basker, Dec 1982). Maintenance workers should be used at the Naval Academy wherever possible. Regrettably the concept of a maintenance worker is not openly welcomed at the Academy because it represents a philosophical shift in the way business is done. There is also the ominous obstacle of getting the personnel recruitment through the civilian personnel office at a high enough pay level to attract quality people. Nevertheless, after considering and planning for training requirments, organizational changes and union problems, the Academy should attempt hiring some maintenance workers. They could be effectively used in those locations where assigning one or two full-time maintenance employees responsible for all routine PM and emergency/service work makes sense.

5.4 Data Collection

Maintenance Data should provide the mechanic and management with the information necessary to reach intelligent decisions. Probably the most troublesome issues in data collection are the frequent lack of uniform reporting over time and the accumulation of and exposure to extraneous data. Consistent and concise PM and breakdown historical data are essential to both mechanic and management, albeit sometimes at different levels of

aggregation. The most important input comes from the mechanic whether he is inspecting or repairing a piece of equipment. But he cannot be expected to write a dissertation on each and every piece of equipment he services, nor would management be likely to absorb such information on many pieces of equipment. The hard card provided a convenient way for the mechanic to indicate, using simple checkmarks, what actions he performed during PM. The card then provided a snapshot of the equipment's PM history for management. There was not, however, an easy or quick way of correlating, or in some cases even finding, relevant records of equipment failure. The paper sheet system exacerbated the problem of recording and analyzing equipment performance by not providing room for remarks, and by not carrying over information from previous inspections. The BEST system does not much improve PM in these areas.

What is needed is a system which uniquely identifies each piece of equipment, automatically correlates PM and breakdown information, is easy to use for the mechanic, and is helpful to management. An example of one part of such a system is the work order provided in exhibit 5-1. This form, which is partially filled in by the computer and partially by the mechanic, is easy to use and also capable of being read by a computer card scanner which is tied into the management system. This has the tremendous advantage of eliminating the need to manually transfer data.

Exhibit 5-1. Proposed Form of PM Work Order

Job number: 123
Building: 89
Checkpoints: 1. Check oil
2. Lube
Standard Hours: 2.5
Actual Hours: __ __ . __

(Fill in top and put an "X" in proper boxes)

0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9

Your ID #: __ __ __ __

(Fill in top and put an "X" in proper boxes)

0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

Item	1		2	
Last PM Date	3/5/85		3/5/85	
E/S Calls Last Qtr	0		2	
PM Action: (Indicate action taken with "X" in boxes)	This PM	Last PM	This PM	Last PM
Inspected only		X		
Changed filter				
Added oil				X
Lubed				X
Adjusted belts				
Checked bearings				
Realigned				
Tightened Supports				
Major Repair Done				
Not in Service				
Couldn't find				
Equipment removed				
Equipment changed				
Needs an E/S Call				
Other (please specify below)				

Item	Name	Location
1	Unit htr	NE corner of gym ceiling
2	Unit htr	SW corner of gym ceiling

Equipment PM history, time card information for employee pay purposes, and employee productivity results are displayed for the mechanic or captured for management. Although this would represent a significant change in the way PM is done, it is technologically feasible (as attested to by numerous state lottery systems, among other applications) and perhaps necessary as the number of civilian workforce positions decline over time while the workload grows due to the increasing complexity of building mechanical systems. A similar type of card could be used for emergency/service work orders which would also feed into the computer management system. The size and cost associated with such a computer system would be dependent upon the size of the individual Navy activity which uses the system. Similar to the BEST arrangement, control over the system should remain with the Public Works Departments. This would help to ensure that real time information and easy access to that information is provided to those personnel needing it most.

5.5 Equipment History

The generation and use of equipment history records permeates the other elements of a preventive maintenance system. It is universally recognized as a vital component in the overall scheme of equipment maintenance, but is rarely adequate, up to date or effectively analyzed (de Matteis, 1982). As the issue is addressed in the other sections of this chapter, it is highlighted here only to

stress further its importance.

5.6 Cost Accounting

Financial terms are often the only common language among managers responsible for different functions within an organization. The advantages of improved reliability and productivity resulting from a PM program must be stated in cost to benefit relationships, payback ratios and present value analyses in order to win the full respect and support of top management. The Naval Academy, like most small Navy activities, has the costs associated with the PM program spread out over many areas, making such analyses almost impossible. PM and emergency/service job orders, the current bases for cost accounting purposes, often cover entire buildings or systems, and contain information in too aggregate a form to be of much use in any cost analysis. The most serious flaw in the BEST system is that it contains no cost expenditure information anywhere in the program! One or more forms of the scanner read card proposed in a previous section would directly tie equipment costs to timecards and eliminate much of the administrative duplication that is required today for job order and time card reporting purposes.

5.7 Management Information

Although the capability exists to overwhelm management with facts and figures using a computer based maintenance management system, a few simple and concise reports with some information in graphic form would probably be more

useful. Allowing the system's users to easily query the database and extract their own information in suitable formats would be an invaluable management tool, particularly if the selection routines could be stored in memory for repeated use. The database structure incorporated into the system should allow quick and easy access to the important criteria mentioned in this study.

One of the big problems noted with the BEST PM system is its inability to easily combine breakdown and PM equipment histories into a functional form. Ideally the PM user should be able to identify a piece or category of equipment and have the computer system print out a complete maintenance history using charts, tables and other forms of information as appropriate. Since there is not enough time to inquire about every piece of equipment in a PM program, however, some form of exception reporting should be built into the system. For example, a monthly printout of equipment experiencing failure in each of the last two months or quarters might indicate problems which should be further investigated. Numerous algorithms could be programmed into the system to provide valuable exception reports. General equipment summary reports in some areas could also be provided.

Another important management function is to monitor the performance of its employees. As the necessary labor time information was collected in a previous section, this now becomes an easy reporting procedure for the system.

The level of aggregation would be dependent upon the organization and philosophy of the activity. Exception reporting could be used in this area as well.

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

The Naval Academy has achieved the efficient operation of its installed building mechanical equipment somewhat at the expense of maintenance and fiscal efficiency. By relying on conservative estimates for the scheduling frequencies of PM inspections, the Academy has unwittingly attempted to over maintain much of its equipment based on the equipment history records for the period January 1979 through March 1985 in selected buildings. The PM program at the Academy is not unique in that it suffers from some of the same problems affecting other maintenance organizations the world over, i.e., maintenance managers are overworked, PM does not receive a high priority, scheduling frequencies are inefficient, costs are not fully accounted for and the motivation for PM personnel to adhere to the program is sometimes lacking. The shift to a new PM organizational arrangement and two new administrative systems in the past three years has further complicated the PM program's problems.

The Academy has recently begun critically reviewing its preventive maintenance program. The five most important recommendations for PM program improvement, described in detail in previous chapters, are provided for the Academy's consideration.

1. PM inspection frequencies should be drastically reduced in light of the mechanical equipment histories

studied. With the exception of air compressors, virtually no other single piece of equipment failed in consecutive quarters regardless of whether PM was routinely performed or not. Most monthly checks could be done quarterly and most quarterly checks could be done semiannually with little or no effect on equipment performance. The very few pieces of extremely critical equipment should remain on their present inspection schedule. After this drastic cut is made, the program will be more manageable and it will be easier to make further analyses and system improvements.

2. Two or three mechanics should be permanently assigned on a trial basis to a building or group of buildings, e.g., Michelson-Chauvenet Halls, and given full responsibility for all routine PM and emergency/service work requirements. It is envisioned that the results of the experiment and the input of the assigned mechanics would prove invaluable toward further system improvement. These same mechanics might also be able to apply the principles of reliability centered maintenance to their area, and the Academy could then expand their findings to the entire PM program.

3. A major concern is of the usefulness of the new BEST computer system as it applies to the PM program. Major improvements need to be made to the system before it reaches its potential, but the Academy's mechanical equipment still requires PM service in the interim. If BEST cannot be used to maintain equipment historical

records immediately, then the Academy should revert back to the old PM hard cards. Some of the improvements recommended for BEST include increased PM scheduling capability, better interface between the E/S and PMI modules, graphics, cost accounting features, card scanners, and quicker and easier database access.

4. Clerical support should be provided, at least on a part-time basis, for the PM program administrator in the Maintenance Control Division. This would help free up the administrator from some of his menial tasks and allow him to concentrate on important PM equipment related issues.

5. The concept of multi-skilled maintenance workers should be re-examined.

The Naval Academy's Public Works Department is staffed by highly motivated and experienced professionals who have identified and are correcting the problems in their PM program. It is crucial that they continue to focus on the solutions which will save money overall and make things simple for all of those involved in the program.

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APPENDIX A

ABBREVIATIONS USED

AC	Air conditioning unit
AHU	Air handling unit
AIRCOM	Air compressor
ATCCOM	ATC compressor
AUXCIR	Auxiliary circulating pump
BLRCIR	Boiler circulating pump
BLR FD	Boiler feed pump
CABFAN	Cabinet fan
CABHTR	Cabinet heater
CHEMFD	Chemical feed
CIRC	Circulating pump
CL TWR	Cooling tower
COND	Condensate pump
CW	Chill water
CWCIRC	Chill water circ pump
CW RTN	Chill water return pump
CW SUP	Chill water supply pump
DISTWT	Distilled water
DISTRI	Distribution pump
EJTR	Ejector pump
EVAP	Evaporator
EXHBLO	Exhaust blower
EXHFAN	Exhaust fan
F DFT	Forced draft fan
FD WTR	Feed water
FO TRN	Fuel oil transfer
FUELOI	Fuel oil
FW	Fresh water
HTR/AC	Heater & AC wall unit
HUMID	Humidifier
HVAC	Heating, ventil & AC
HVU	Heating & ventilating unit
HWCIRC	Hot water circ pump
HWS	Hot water system
HYDRAU	Hydraulic
INDDRA	IND draft fan
MAINCI	Main circulating pump
MAKEUP	Make up feed water
MR	Mechanical room
MTRDRV	Motor Driven
PENTHS	Penthouse
PRECOT	Precoat
RAF	Return air fan
RF FAN	Roof fan
ROOFEX	Roof exhaust
SLRYFD	Slurry feed
SOOTBL	Soot blower
STCLNR	Steam cleaner
STMGEN	Steam generator mixer
SUPAIR	Supply air
SUPLIN	Supply line
TUNL	Tunnel
UNIHTR	Unit heater
UNK	Unknown
VENT	Ventilation
WALLU	Wall unit
WTRCON	Water conditioner
WTREXC	Water exchanger

FREQUENCIES

W = Weekly
M = Monthly
Q = Quarterly
SA = Semiannually
A = Annually

P = INSPECTION PERFORMED   A: ACTION PERFORMED DURING INSPECTION   B: BREAKDOWN

BLDG. 277 [illegible] PM

1

CARD NO.	DESCRIPTION	PM		1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
76	A.E. [illegible]	M	.2															PAP	P	PP	PNAP	PPAP	PPA	PP				
77	" [illegible]	M	.2															PP	P	PP	PPP	PPAP	PP	PP				B
[illegible]	" [illegible]	M	.2						P	P		PP		P	P	P		PP	P	PP	PPP	PPP	PP	PP				
[illegible]	" "	M	.2						P	P		PP		P	P	P		PP	P	PP	PPP	PPP	PP	PP				
[illegible]	" [illegible]	M	.4	P		PPB	PP	P	P	PPB		PP			P	P		PPB	PBB	PP	PBPP	PBBB		P	B	B	B	
81	" "	M	.4				BB	B	B	BB								PAP	BBBB	PAP	PPAPA	PPAP	PPA	BP			BB	BBB
82	" [illegible]	M	.4					B		B								P	PB	PAPA	PP	PPAP	PPPA	PP	B			BP
[illegible]	" "	M	.4					BB	B									PB	PP	PPA	PP	[illegible]	PAA	PP	PB	B		P
[illegible]	" [illegible]	M	.2	B	B													P	P	PP	[illegible]	PAPA	PAA	PP				
[illegible]	" [illegible]	M	.4																PP	PP	PPAP	PPAP	PP	P				P
[illegible]	" [illegible]	M	.5																			PPP	PP	P				
	[illegible]			BB		BPBB	B	B										BB	BB	BBB BBB	BBB BBB	BBB			BBB	B	BBBB BBBB	BBB
192	SUPPLY FAN 1 [illegible]	M	.4	P	P	P	P	P	P	PB		P	P	P	P	P		PP	P	PP	P			P	PP			
193	" 2 "	M	.5	P	PB	P	P	P	P	P		P	P	P	P	P		PP	PB	PP	P				PP			
[illegible]	" 3 "	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P				P			
[illegible]	" 4 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	PB	PP	P		P	P	PP		A	
[illegible]	" 5 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
[illegible]	" 6 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
[illegible]	" 7 [illegible]	M	.5	P	P	P	P	P	P	PB		P	P	P	P	P		PP	P	PP	P			PB	PP	B		
[illegible]	" 8 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
200	" 9 [illegible]	M	.5	P	PB	PBB	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	PB	PP			
[illegible]	" 10 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
[illegible]	" 11 [illegible]	M	.5	P	PB	P	P	PB	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
[illegible]	" 12 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
[illegible]	" 13 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	PB	PPB	P		P	P	PPB	B		
[illegible]	" 14 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	PB	PP			
[illegible]	" 15 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PPB	P		P	P	PP			B
[illegible]	" 16 [illegible]	M	.5	P	PB	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP	PB	BB	
[illegible]	" 17 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
207	" 18 [illegible]	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			B

80

P = INSPECTION PERFORMED   A = ACTION PERFORMED DURING INSPECTION   B = BREAKDOWN

BLDG 590
MACHINE SHOP
(WC 04)
PM

2

CARD NO.	DESCRIPTION	PM FREQUENCY	STANDARD HOURS	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
210	SUMP PUMP 19 SE AC	M	.5	P	P	P	P	P	PB	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
211	" 20 EAST MAKT	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
212	" 21 NE CMA	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
213	" 22 "	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
214	" 23 SW MEAT	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	PB	PP			
215	" 24 "	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
216	" 25 645	M	.5	P	P	P	P	PB	P	P		P	P	P	P	P		PP	P	PP	P		P	P	PP			
217	" 26 "	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P	P		PB	PP			
218	" 27 "	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P	P		P	PP			
219	" 28 "	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P	P	B	P	PP	B		
220	" 29 NWL	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P	PBBB		P	PPB		B	B
221	" 30 SESE	M	.5	P	P	P	P	P	P	P		P	P	P	P	P		PP	P	PP	P	P		P	PP			
	INDETERMINATE SUMP PUMP			B	BBBB	BB	B	BBB		B								BB	BBBBB	BBBBB		B		BBB	BBBBB			B
263	SEWAGE PUMP 1 AERO	M	.5						B					PPP			P	PA	PP	P				P				
264	" 2 AERO	M	.5											PPP		P	P	PA	PP	B				P				
265	" CS1 63	M	.5															P	PP	P	P							
266	" CS2 610	M	.5															P	PP	P	P							
1450	EXHAUST FAN 1 PENT.	Q	.6	P	P	PA	PABB	P	P	P		P	P	P	P	P	P	P	PAB	PA	PAB	P		P				P
1451	" 2 "	Q	.6	P	P	P	P	P	P	P		P	P	P	P	P	PB	P	PA	PA	PB	P		P	B	B		PB
1452	" 3 "	Q	.6	P	P	P	PB	P	P	P		P	P	P	P	P	PA	P	PA	P	P	PA		P	B			P
1453	" 4 "	Q	.6	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P		P	P		P				P
1454	" 5 "	Q	.6	P	PB	P	P	PB	P	PB		P	P	P	P	P	P	P	P	P	P	P		P				P
1455	" 6 "	Q	.6	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				P
1456	" 7 "	Q	.6	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				P
1457	" 8 "	Q	.6	P	P	PAB	PAB	PBB	P	P		P	P	P	P	PA	P	P	PB	P	P	P		P				P
1458	" 9 "	Q	.6	P	PB	P	P	P	P	PB		P	P	P	P	P	P	P	PB	PA	P	P		P				P
1459	" 10 "	Q	.6	P	P	P	P	P	P	P		P	P	P	P	P	P	P	PB	PB	P	P		P				P
1460	" 11 "	Q	.6	PA	P	PBB	P	P	P	P		P	P	P	P	P	P	P	P	P	P	PB		P				P
1461	" 12 "	Q	.6	PA	P	P	PA	P	P	P		P	P	P	P	P	PA	P	PA	PA	P	P		P				P
1462	" 13 "	Q	.6	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				P

P = INSPECTION PERFORMED   A: ACTION PERFORMED DURING INSPECTION   B: BREAKDOWN

BLDG 590
MACHINE SHOP
(WC 04)
PM

3

CARD NO.	DESCRIPTION	PM FREQUENCY	STANDARD HOURS	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
1463	EXHAUST FAN 14	Q	.6	P	P	P	PA	P	P	P		P	P	P	P	P	P	P	PA	PA	P	PA		P				P
1464	15	Q	.6	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				P
1465	16	Q	.6	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				P
1466	17	Q	.6	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				P
1467	18	Q	.6	P	P	P	P	P	P	P		P	P	P	P	P	P	P	PA	PA	P	PA		P				P
1468	COOL TOWER 7-1	Q	.6		P		P	P	P	P		P	P	P	P	P	P	PA	P	P	P	P		PB	B			P
1469	7-2	Q	.6		P		P	P	P	P		P	P	P	P	P	P	P	P	P	PB	P		P				P
1470	7-3	Q	.6		P		P	P	P	P		P	P	P	P	P	P	PA	P	P	P	P		P				P
1471	7-4	Q	.6		P		P	P	P	P		P	P	P	P	P	P	PA	P	P	P	P		PB				P
1472	8-1	Q	.6		P		PA	P	P	P		P	P	P	P	P	P	PA	P	P	P	P		P				P
1473	8-2	Q	.6		P		PA	P	P	P		P	P	P	P	P	P	P	P	P	P	P		PB				P
1474	8-3	Q	.6		P		PA	P	P	P		P	P	P	P	P	P	PA	P	P	P	P		PB				P
1475	8-4	Q	.6		P		PA	P	P	P		P	P	P	P	P	P	P	PA	P	P	P		P				P
1476	9-1	Q	.6	PA	P		P	P	P	PA		P	P	P	P	P	P	P	P	P	P	P		PB				P
1477	9-2	Q	.6	PA	P		P	P	P	PA		P	P	P	P	P	P	P	P	P	P	P		P				P
1478	9-3	Q	.6	PA	P		P	P	P	PA		P	P	P	P	P	P	P	P	P	P	P		P				P
1479	9-4	Q	.6	PA	P		P	P	P	PA		P	P	P	P	P	P	PA	P	P	P	P		P				P
1480	10-1	Q	.6	PA	P		P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P	B			
1481	10-2	Q	.6	PA	P		P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				
1482	10-3	Q	.6	PA	P		P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		PB	B			
1483	10-4	Q	.6	PA	P		P	P	P	P		P	P	P	P	P	P	P	PA	P	P	P		P				
1484	EXH FAN, 15HP	Q	.6	PA	P		P	P	P	P		P	P	P	P	P	P	P	PA	PB	P	P		P				
1485	25HP	Q	1.5	PA	P		P	P	P	PA		P	P	P	P	P	P	PB	PA	P	P	P		P				
1486	15HP	Q	1.5	P	P		PA	P	PB	P		P	P	P	P	P	P	PAB	P	P	P	P		P				
1487	1HP	Q	1.0	P	P		P	PA	P	P		P	P	P	PA	PA	P	PA	PA	P	P	PA		P	B			P
1488	.5HP	Q	.6	P	P		P	P	P	P		P	P	P	P	P	P	P		P	P	PA		P				P
1489	1HP	Q	.6	P	P		P	P	P	P		P	P	P	P	P	P	P		P	P	PA		P				P
1490	PUMP HOUS P5	Q	.5	P	P		PA	P	P	P		P	P	P	P	P	P	P	PB	PA	P	PA		P				PP
1491	PUMP HOUS P6	Q	.5	P	P		P	P	P	P		P	P	P	P	PA	P	P	PB	PA	P	PA		P				PP
1492	PUMP HOUS P7	Q	.5	P	P		PB	P	P	P		P	P	P	P	PA	P	P	PB	PA	P	P		P	B			PBP

P = INSPECTION PERFORMED A: ACTION PERFORMED DURING INSPECTION B: BREAKDOWN

BLDG 590
MACHINE SHOP (WC 04)
PM

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CARD NO.	DESCRIPTION	PM FREQUENCY	STANDARD HOURS	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
1493	PUMP, HW NE ZONE	Q	.5	P	P	P	PA	P	P	P		P	P	P	P	PA	PA	P	PB	PA	P	PA		P				P
1494	RAF 3	Q	1.0	P	P	P	P	P		P		P	P	P	P	P	PA	P	P	P	P	PA		P				PP
1495	AHU 7	Q	1.0	P	P	P	P	P		P		P	P	P	P	P	P	P	PA	PA	PBB	P		P				PP
1496	AHU 3	Q	1.0	P	P	P	P	PB		P		P	P	P	P	P	PA	P	PB	PB	P	P		PB				PP
1497	AHU 2	Q	1.0	P	P	P	P	P		PBB		P	P	P	P	P	PA	P	P	P	P	P		P	BB			PP
1498	AHU 5	Q	1.0	PA	P	P	P	P		P		P	P	P	P	P	P	P	P	PA	P	P		PB				PP
1499	RAF 2	Q	1.0	P	P	P	P	P		P		P	P	P	P	P	P	P	P	PA	P	P		P				PP
1500	PUMP, ZONE 2	Q	.5	PA	P	P	PA	P		P		P	P	P	P	PA	PA	PAB		P	PB	PA		P				PPB
1501	PUMP, ZONE 1	Q	.5	P	P	P	P	P		P		P	P	P	P	PA	PA	PAB		PA	P	PAB		P				PP
1502	PUMP, HW CIRC	Q	.4	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				PP
1503	"	Q	.4	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				PP
1504	WATER DISTILLER	Q	1.5	P		P	PB		P	PB			P		P	P	P	PB	P	P	P	P		PB	B			PP
1505	RAF 1	Q	1.0	PA	P	PBB	P	P		PB		P	P	P	P	P	P	P	P	P	P	P		P				PP
1506	AHU 6	Q	1.0	PA	P	P	P	P		P		P	P	P	P	P	P	P	PBB	P	P	P		P	BB			PPB
1507	AHU 1	Q	1.0	P	P	P	P	P		P		P	P	P	P	P	P	P	PAB	P	P	P		P				PP
1508	AHU 4	Q	1.0	PB	P	P	PBBB	PB		P		P	P	P	P	PA	P	P	P	P	PBB	P		P	BB		B	P
1509	PUMP, STM GEN 1	Q	.5	P	P	P	P	P	P	P		P	P	P	P	P			P	P	P	P		P				P
1510	" 2	Q	.5	P	P	P	P	P	P	P		P	P	P	P	P			P	P	P	P		P				P
1511	PUMP, FW1	Q	.5	P	P	P	P	P	P	P		P	P	P	P	P	P	P		P	P	P		P				P
1512	PUMP, FW2	Q	.5	P	P	P	P	P	P	P		P	P	P	P	P	P	P		P	P	P		P				PP
1513	RAF 4	Q	1.0	P	P	P	PA	P	P	P		P	P	P	P	P	P	P	P	PA	P	P		P				PP
1514	PUMP HWS P4	Q	.5	P		P	P	P	P	P		P	P	P	P	P	PA	P	P	P	P	P		P				PP
1515	PUMP HW CIRC	Q	.4	P	P	P	P	P		P		P	P	P	P	P	P	P	P	P	P	P		P				PP
1516	ROLL O-VENT FAN	Q	.7	PA	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				PP
1517	"	Q	.7	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				PP
1518	"	Q	.7	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				PP
1519	"	Q	.7	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				PP
1520	PUMP, STM GEN 1	Q	.4	P	P	P	P	P	P	P		P	P	PA	P	P	P	P	P	P	P	P		P				PP
1521	PUMP BLR FD	Q	.5	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				PP
1522	PUMP, BLR FD	Q	.5	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				PP

P = INSPECTION PERFORMED   A = ACTION PERFORMED DURING INSPECTION   B = BREAKDOWN

BLDG 570
MACHINE SHOP
(WC 04)
PM

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CARD NO.	DESCRIPTION	PM FREQUENCY	STANDARD HOURS	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
1523	PUMP HW CIRC	Q	.5															P	P	P	P	P		P				PBP
1524	PUMP HW CIRC	Q	.5															P	P	P	P	P		P				PP
1525	PUMP CIRC	Q	.5	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P				PP
1526	PUMP CW CIRC	Q	.4						B									P	P	P	P	P		P				PP
1527	PUMP CW SUP	Q	.5															P	P	P	P	P		PB				PPA
1528	"	Q	.5															P	P	P	P	P		P				PP
1529	"	Q	.5															P	P	P	P	P		P				PP
1530	"	Q	.5															P	P	P	P	P		P				PP
1531	AHU 11	Q	.5															P	PA	P	PB	P		PB				PP
1532	CAB FAN 6	Q	.5															P	PA	P	P	P		P				PP
1533	CAB FAN 10	Q	.5															P	P	P	P	P		P				PP
1534	AHU 16	Q	.5															P	PA	P	P	P		P				PP
1535	AHU 13	Q	.5															P	PA	P	P	P		PB	B			PP
1536	CAB FAN 7	Q	.5															P	PA	P	P	P		P				PP
1537	AHU 14	Q	.5															P	P	P	P	P		P	B			PP
1538	CAB FAN 18	Q	.5															P	PA	P	P	P		P				PP
1539	SUP AIR FAN	Q	1.0						P	P	P	P		P		P	P	P	P	P	P	P		P				P
1540	PUMP, CL TWR WATER	Q	.5															P	P	P	P	P		P				P
1541	AHU 10	Q	1.0							B									P	PBB	P			P				
1542	AHU 9	Q	1.0																P	P	P			P				P
1543	AHU 5 [illegible]	Q	1.0																P	P	P	P		P				P
1544	[illegible]	Q	.4																P	P	P	P		P				
1545	WALL [illegible]	Q	.4																P	P	P	P		P				
1546	EXH FAN	Q	.4						B	B									P	P	P	[illegible]		P				
1547	AHU 8	Q	1.0																P	P	P			P				
1548	AHU 3	Q	1.0			B	B												P	P	P			P				
1549	EXH FAN 18	Q	.5	P	P	PA	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P						PBP
1550	17	Q	.5																	P	P	P		P				PP
1551	16	Q	.5	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P				PP
1552	15	Q	.5	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P				PF

P = INSPECTION PERFORMED A = ACTION PERFORMED DURING INSPECTION B = BREAKDOWN

BLDG. 570 [illegible] PM 6

CARD NO.	DESCRIPTION	STANDARD HOURS	FREQUENCY	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-85	1-85
[illegible]	[illegible] 14	[illegible]	.5	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P				PP
[illegible]	13	[illegible]	.5	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P				PP
[illegible]	12	[illegible]	.5	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P				PP
[illegible]	11	[illegible]	.5	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P				PP
[illegible]	10	[illegible]	.5	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P				PP
[illegible]	1	[illegible]	.5	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P				PP
[illegible]	2	[illegible]	.5	PA	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P				PP
[illegible]	[illegible]	[illegible]	[illegible]				NEVER	INSPECTED	–			PORTING		SCAFFOLDING												BB	B	B
[illegible]	[illegible]	[illegible]	[illegible]																P	P	P			P				
[illegible]	[illegible]	[illegible]	[illegible]																PB	P	P			P				
[illegible]	[illegible]	[illegible]	.5															P		P	P	P	P	P				PP
[illegible]	[illegible]	[illegible]	.5															P		P	P	P	P	P				PP
[illegible]	[illegible] 1	[illegible]	.5					A										P		P	P	P	P	P				PP
[illegible]	[illegible] 2	[illegible]	.5															P		P	P	P	P	P				PP
[illegible]	[illegible] 4	[illegible]	.5	P	P	P	P	P	P	P		P	P	P	P	P	P	P		P	P			P				P
[illegible]	3	[illegible]	.5	P	P	P	P	P	P	P		P	P	P	P	P	PA	P		P	P			P				P
[illegible]	NOT USED																											
[illegible]	[illegible]	[illegible]	[illegible]															P		P	P	P	P	P				PP
[illegible]	[illegible]	[illegible]	.5																P	P	P	P		P				P
[illegible]	[illegible]	[illegible]	.5																P	P	P	P		P				P
[illegible]	[illegible]	[illegible]	[illegible]	P	P	P	P	P	P	P		P	P		P	P	P	P		P	P		P	P				P
[illegible]	[illegible]	[illegible]	[illegible]															PB	P	P	P			P				PP
[illegible]	[illegible]	[illegible]	[illegible]															P	P	P	P			P				PP
[illegible]	[illegible]	[illegible]	.7															P	P	P	P	P		P				PP
[illegible]	[illegible]	[illegible]	.7															P	P	P	P	P		P				PP
[illegible]	[illegible]	[illegible]	.7															P	P	P	P	P		P				PP
[illegible]	[illegible]	[illegible]	.7															P	P	P	P	P		P				P
[illegible]	[illegible]	[illegible]	1.4	P	P	P	P	P	P	P		P	P	P	P	P	P	B	P	PBR	PB			P			B	P
[illegible]	[illegible]	[illegible]	.5	P	P	P	P	P	P	P		P	P	P	P	P	P	P		P	P	P		P				PP
[illegible]	"	[illegible]	.5	P	P	P	P	P	P	P		P	P	P	P	P	P	P		P	P	P		P				PP

P = INSPECTION PERFORMED A: ACTION PERFORMED DURING INSPECTION B: BREAKDOWN

7

CARD NO.	DESCRIPTION	STANDARD HOURS	FREQUENCY	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
[illegible]	[illegible]	[illegible]	[illegible]	P	P	P	P	P	P	P	—	P	P	P	P	P	P	P		P	P	P		P				
[illegible]	[illegible]	[illegible]	[illegible]																	P	P	P		P				
[illegible]	[illegible]	[illegible]	[illegible]										P	P	P	P				P		P						
[illegible]	[illegible] ARMS	[illegible]	[illegible]										P	P	P	P				P		P						
[illegible]	[illegible]	[illegible]	[illegible]			B	B	B	B	B												B		B		B	B	
1-387	[illegible]	[illegible]	[illegible]	P	PP	P	P	P	P		P		PPP	P	P	P	P	PPPP	PP		P							
	HVAC UNITS –			(EACH OF 327 UNITS)						(INDIVIDUAL BREAKDOWNS																		
	#1 – #327				B	BBBB	B		BBBB	BB									BB	BB	BB	BBB BBB		BBB	BBBB BBBBB	BBBB		BBB BBB
	[illegible]			B				B														B		B	B	B	B	BBB
	[illegible]						BB											B				B			BB			
	[illegible]			BB	BB	BBB	BB	BB	B	BB	(NO PM PERFORMED)							BBB	BBB	BBB	BBB	BB		BBB	B[illegible]B	BB	BBBB	BBB

P = INSPECTION PERFORMED A = ACTION PERFORMED DURING INSPECTION B = BREAKDOWN

BLDG 579 MACHINE SHOP (WC 94) PM 8

CARD NO.	DESCRIPTION	FREQUENCY	STANDARD HOURS	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
72	AIR COMPRESSOR 1, 20HP	M	.2			B												P		PP	P	PP		PP				P
73	" 2, 20HP	M	.2															P		PF	P	PP		PF				P
74	" 1, 2HP	M	.2															P		PP	PA	PAB		PF	B			P
75	" 2, 2HP	M	.2															P	B	PFB	PA	PP	B	PP		B		P
222	SUMP PUMP 1	M	.4	P	P	PB	P	P	P	P	P		P	P		P	P	PP	P	PP	P		P	PP	P			
223	2	M	.4	P	P	PB	PP	P	PA	P	P		P	P		P	P	PP	P	PP	P		P	PP	P			
1217	VALVE, MIXER #4	Q	.5	P	P	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P		P	P		P
1218	" 3	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P						P	P		P
1219	" 2	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P	P		P
1220	" 1	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P	P		P
1221	HEAT, UNIT HTR 6	A	.5	P		P	P	P		P				P			P		P	P			P					
1222	" 5	A	.5	P		P	P	P		P				P			P	P		P			P					
1223	" 4	A	.5	P		P	P	P		P				P			P	P		P			P					
1224	" 3	A	.5	P		P	P	P		P				P			P	P		P			P					
1225	" 2	A	.5	P		P	P	P		P				P			P	P		P			P					
1226	" 1	SA	.5	P	P	P	P	P	P	P	P		P	P		P	P			PBB			P	B				
1227	PUMP, CHEM FD	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	PB	P	PB	BB	PB	P		P
1228	DOOR, LIFT	Q	.1	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P	P		
1229	PUMP, ST CELL 3	Q	.5	P	P	P	P	PBBB	P	P	P		P	P		P	P	P	P	P	P	P	P		P	P		P
1230	" 2	Q	.5	P	P	P	P	PBB	P	P	P		P	P		P	P	P	P	P	P	P	P		P	P		P
1231	" 1	Q	.5	P	P	P	P	PBB	P	P	P		P	P		P	P	P	P	P	P	P	P		P	P		P
1232	VENT, F DEPT 3	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P	P		P
1233	" 2	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	PBB		P	P		P
1234	" 1	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P	P		P
1235	PUMP, FUEL OIL 2	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P		P	PP
1236	" 1	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P		P	PP
1237	PUMP, LAUNDRY 2	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P		P	PP
1238	" 1	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P	B	P		P	P
1239	PUMP, MAKE UP 2	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	PB	P		P		P	P
1240	" 1	Q	.5	P	P	P	P	P	P	P	P		P	?		P	P	P	P	P	P	P	P		P		P	P

P = INSPECTION PERFORMED A: ACTION PERFORMED DURING INSPECTION B = BREAKDOWN

BLDG 579 MACHINE SHOP (NCOH) PM 9

CARD NO.	DESCRIPTION	PM FREQUENCY	STANDARD HOURS	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
1241	PUMP, FEED 1	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	PB	B	P		P	PP
1242	" 2	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P	B	P		P	PP
1243	PUMP, CIRC 4	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P		P	PP
1244	" 3	Q	.5	P	P	P	P	PB	P	P	P		P	P		P	P	P	P	P	P	P	P		P		P	PP
1245	" 2	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	PB	B		P			P		PB	PP
1246	" 1	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P		P	PP
1247	PUMP, DISTRI 4	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P				P	PP
1248	" 3	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P		P	PP
1249	" 2	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P		P		P	PP
1250	" 1	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P	B	P		P	PP
1251	VENT, SCOT SL 3	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P		P	P		P		P	PP
1252	" 2	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P		P	P		P		P	PP
1253	" 1	Q	.5	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P		P	P		P		P	P
1254	PUMP, FG TRI	Q	.5	PB	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	PB		P		P	P
1255	VENT UNIT R	EA	.5	P	P	P	P	P		P	P			P			P	P		P		P	P		P		P	PP
1256	VENT EXH FAN	Q	1.0	P	P	P	PA		PA	PA	P		PA	PA		PA	P	PA	P	P	P	P	P		P		P	P
1257	VENT EXH FAN 4	Q	1.0	P	P	P	P	P	PA	P	P	PA		P		P	P	PA	P	PA	P	P	PB		P		P	P
1258	" 3	Q	1.0	PB	P	P	PA	P	PA	P	P		PA	P		P	P	P	P	P	PA	P	P		P	B	P	P
1259	" 2	Q	.5	P	P	P	P	P	PA	PB	P		PA	P		P	P	PA	P	PA	P	P	P		P		P	P
1260	" 1	Q	1.0	P	P	PB	P	PB	PA	P	P		PA	P		P	P	P	P	PA	P	P	P		P		P	P
1261	H/AC 2	Q	.7								P	P		P		P	P	P	P	P					P		P	PP
1262	" 1	Q	.7				PB				P		P	P		P	P	P	P	P					P		P	PP
1263	UNITCON	Q	.7													P	P	P	P	P	P	P	P		P		P	P
411	AFTER COOLER	A	1.0																					P				
V01K	[illegible] CONTROL	?	?		B														BB			B	B					
V010	INTERMEDIATE H[illegible]					BB												B					BBB		BBBB			
V01K	INTERMEDIATE [illegible]																					B						

P = INSPECTION PERFORMED　　A: ACTION PERFORMED DURING INSPECTION　　B = BREAKDOWN

BLDG S 71
[illegible]
PM

10

CARD NO.	DESCRIPTION	FREQUENCY	STANDARD HOURS	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
[illegible]	Air compressor	M	.4															PPA	PAB		PPAA	FA	PPAA					
66	"	M	.4															PPA	P	PPPA	PPP AAA	PPPA	PPA	PP				P
67	"	M	.4															PPA	PA	PA	PPA	PPP AAA	PPA	PP				
27	"	M	.2																	P	PAB	PP		P			B	
26	"	M	.2																	P	PA	PP		P				P
[illegible]3	"	M	.2																					PP				
[illegible]	[illegible]	[illegible]	[illegible]																									
[illegible]	Pump [illegible] 1	SA	.4		P			P				P		P		P	P		P		P	B						PP
[illegible]	" 2	SA	.4		P			P				P		P		P	P		P		P							PP
[illegible]	" 3	SA	.4		P			P				P		P		P	P		P		P							PP
[illegible]	" 4	SA	.4		P			P				P		P		P	P		P		P							PP
[illegible]	[illegible] 3	SA	.2		P			P				P		P		P			P		P				B			PP
1040	[illegible]	SA	.7		P			P						P		P			P		P							PP
1041	"	SA	.7		P			P						P		P	P		P		P							PP
1042	"	SA	.7		P			P						P		P			P		P							PP
1043	"	SA	.7		P			P						P		P			P		P							PP
[illegible]	Pump circ	SA	.4		P			P						P		P		P		P								PP
[illegible]	"	SA	.4		P			P						P		P	P		P	B	P							PP PP
[illegible]	"	SA	.4		P			P						P		P			P		P							PP
[illegible]	"	SA	.4		P			P						P		P			P		P							PP
[illegible]	[illegible] 1	SA	.7		P			P						P		P			P		P							PP
[illegible]	" 2	SA	.7		P			P						P		P			P		P							PP
[illegible]	"	SA	.7		P			P				P		P		P	P		P		P							PP
[illegible]	"	SA	.7		P			P						P		P			P	B	P							PP
[illegible]	Vent [illegible]	SA	.5		P			P						P		P			P	B	P							PP
[illegible]	[illegible] 1	SA	.7		P			P						P		P			P		P							PP
[illegible]	" 2	SA	.7		P			P						P		P			P		P							PP
[illegible]	[illegible] 1	SA	.7		P			P						P		P			P		P							PP
[illegible]	" 2	SA	.7		P			P						P		P			P	B	P							PP
[illegible]	Pump circ 1	SA	.4		P			P						P		P			P		P							P

P = INSPECTION PERFORMED A: ACTION PERFORMED DURING INSPECTION B: BREAKDOWN

BLDG 571 [illegible] PM

PM 11

CARD NO.	DESCRIPTION	FREQUENCY	STANDARD HOURS	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
[illegible]	[illegible] 2	SA	.4		P			P	P					P		P			P		P							P
1557	[illegible] 1	SA	.5		PA			P	P					P		P			P		P							P
[illegible]	" 2	SA	.7		P			P	P					P		P			P		P							PP
[illegible]	[illegible]	SA	.7		P			P	P					P		P			P		P							P
[illegible]	[illegible] 1	SA	.7		P			P	P					P		P			PA		P							P
[illegible]	" 2	SA	.7		P			P	P					P		P			P		P							P
[illegible]	" 3	SA	.7		P			P	P					P		P			P		P							P
[illegible]	[illegible]	SA	.7		P			P	P					P		P			P		P							P
[illegible]	[illegible]	SA	.5		P			P	P					P		P			P		P							P
[illegible]	[illegible] 1	SA	.7		P			P	P					P		P			P		P							P
[illegible]	" 2	SA	.7	B	P			P	P					P		P			P		P							P
[illegible]	[illegible] 1	SA	.4		P			P	P					P		P			P		P							P
[illegible]	" 2	SA	.4		P			P	P					P		P			P		P							P
1011	[illegible]	SA	[illegible]		P			P	P					P		P			P		P							P
[illegible]	"	SA	.7		P			P	P					P		P			P		P							P
1013	[illegible] 1	SA	.7		P		B	PBB	P			P		P		P			P		P		B	B	B			P
1074	[illegible] 1	SA	.4		P			P	P			P		P		P			P		P							P
1075	[illegible] 1	SA	[illegible]		P			P	P					P		P			PA		P							P
[illegible]	" 2	SA	[illegible]		P			P	P					P		P			PA		P							P
[illegible]	[illegible] 1	SA	.5		P			P	P					P		P			P		P							P
[illegible]	" 2	SA	.5		P			P	P					P		P			P		P							P
[illegible]	" 3	SA	[illegible]		P			P	P					P		P			P		P							P
[illegible]	[illegible] 2	SA	.7		P			P	P			P		P		P			P		P							P
[illegible]	" 3	SA	.7		P			P	P					P		P			P		P							P
[illegible]	" 4	SA	.7		P			P	P					P		P			P		P							P
[illegible]	" 5	SA	.7		P			P	P					P		P			P		P							P
[illegible]	" 6	SA	.7		P			P	P					P		P			P		P							P
[illegible]	" 7	SA	.7		P			P	P					P		P			P		P							P
[illegible]	" 8	SA	.7		P			P	P					P		P			P		P							P
[illegible]	" 9	SA	.7		P			P	P					P		P			P		P							P

P = INSPECTION PERFORMED A: ACTION PERFORMED DURING INSPECTION B = BREAKDOWN

BLDG. 571 MACHINE SHOP [illegible] PM 12

CARD NO.	DESCRIPTION	FREQUENCY	STANDARD HOURS	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
1022	[illegible]	A	.7		P			P						P		P	P		P		P							PP
[illegible]	HVU	*	.7	B	P			P						P		P	P		P		P							PP
[illegible]	[illegible]	A	.4		P			P						P		P	P		P		P							PP
[illegible]	[illegible] 1	[illegible]	.5		P			PA						P		P	PA		P								B	PP&B
[illegible]	" 2	A	.5		PA			PA						P		P	P		PA		P							PP
[illegible]	" 3	A	.5		P			P						P		P	P		PA		P							PP
[illegible]	" 4	A	.5		P			P						P		P	PA		P		P							PP
[illegible]	" 5	A	.5		P		P	P					P		P	P			P		P							P
[illegible]	" 6	A	.5		P			P						P		P	P		P		P							P
[illegible]	" 7	A	.5		PA			P						P		P	P		P		P							PP
[illegible]	" 8	A	.5		P			P						P		P	PA		P		PA							PP
[illegible]	" 9	A	.5		P			P						P		P	PA		PA		P							PP
[illegible]	" 10	A	.5		P			PA						P		P	P		PA		P							PP
[illegible]	11	A	.5		P			P						P		P	P		P		P							PP
[illegible]	12	A	.5		P			P								P	P		P		P							PP
[illegible]	[illegible]	[illegible]	[illegible]		PB	B	B	PB						P		P			PA	PPB PBB	PB	BBB	BPP	PP	B		B	P
[illegible]	[illegible]	A	.4		P			P				P	P			P			P		P							PP
[illegible]	" 13	A	[illegible]		P			P						P		P	P		P		P							PP
[illegible]	[illegible] 1	A	.5		P			P				P		P		P	P		P		P							PP
[illegible]	" 2	A	.5		P			P				P		P		P			P		P							PP
[illegible]	" 13	A	.5		P			P				P		P		P	P		P		P							PP
[illegible]	" 4	A	.5		P			PA				P		P		P			P		P							PP
[illegible]	" 5	A	.5		P			P				P		P		P					P							PP
[illegible]	[illegible] 2	A	.4		P			P						P		P			P		P							PP
[illegible]	" 1	A	.4		P			P						P		P			P		P							PP
[illegible]	" [illegible]	[illegible]	[illegible]		P			P						P		P			P		P							PP
[illegible]	" 2	A	.4		P			P						P		P			P		P							PP
[illegible]	[illegible]	A	.7		P			P						P		P			P		P							PP
[illegible]	"	A	.3		P			P				P		P		P			P		P							PP
[illegible]7	[illegible] 2	A	[illegible]		P			P				P		P		P			P		P							P

P = INSPECTION PERFORMED   A: ACTION PERFORMED DURING INSPECTION   B = BREAKDOWN

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CREW NO.	DESCRIPTION	STANDARD HOURS	FREQUENCY	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
[illegible]	[illegible]	[illegible]	[illegible]		PA			PE	P					P		P			P		P							PP
[illegible]	[illegible]	[illegible]	[illegible]													P	P		PE	P	P			P				PP
[illegible]	AC	[illegible]	[illegible]																					PP				
[illegible]	AC	[illegible]	[illegible]																					P				

P = INSPECTION PERFORMED   A: ACTION PERFORMED DURING INSPECTION   B: BREAKDOWN

BLDG E1 · PM · 14

EQUIP NO.	DESCRIPTION			1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
[illegible]	[illegible] 1	[illegible]	[illegible]									P	PP	PPP	PPP	PP	P	PP	PP	PPP	PP	PPP	PPP	PP	PP			P
[illegible]	" 2	[illegible]	[illegible]									PP	PPP	PPP		PP	P	PPP	PPP	PPP	PP	PPP	PPP	PPP	PP			P
[illegible]	[illegible]	[illegible]	[illegible]																									
[illegible]	[illegible]	[illegible]	[illegible]																									
[illegible]	[illegible] 1	[illegible]	[illegible]																									
[illegible]	2	[illegible]	[illegible]																									
[illegible]	3	[illegible]	[illegible]																									
[illegible]	[illegible] 1	[illegible]	[illegible]																									
[illegible]	2	[illegible]	[illegible]			B																						
[illegible]	3	[illegible]	[illegible]																									
1910	[illegible]	[illegible]	[illegible]	P	P	P		P	P			P		P		P	P		P		P							
1911	[illegible]	[illegible]	[illegible]	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P			P				
[illegible]	[illegible]	[illegible]	[illegible]	P	P	P	P	P	P	P	P	PA	P	P	P	PA	P	P		P	P			P				
[illegible]	[illegible]	[illegible]	[illegible]	P	P	P	P	P	P	P	P	PA	P	P	P	P	P	P	P	P	P			P				
[illegible]	[illegible]	[illegible]	[illegible]	P	P	P	P	P	P	P	P	PA	P	P	P	PA	P	P		P	P			P				
[illegible]	[illegible]	[illegible]	[illegible]	P	P	P	P	P	PA	PA	P	PA	P	P	P	P	P	P	PAB	P	P			P				
[illegible]	"	[illegible]	[illegible]	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	B		P				
[illegible]	"	[illegible]	[illegible]	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P			PA				
[illegible]	[illegible] 1	[illegible]	[illegible]	P	P			P	P			PA		P		P	P			PB								B
[illegible]	2	[illegible]	[illegible]	P	P			P	P			PA		P		P	P		P									B
[illegible]	3	[illegible]	[illegible]	P	P			P	P			PA		P		P	P		P									B
[illegible]	4	[illegible]	[illegible]	P	P			P	P			PA		P		P	P		P									B
[illegible]	5	[illegible]	[illegible]	P	P			P	P			PA		P		P	P		P									
[illegible]	6	[illegible]	[illegible]	P	P			P	P			PA		P		P	P		P									

P: INSPECTION PERFORMED A: ACTION PERFORMED DURING INSPECTION B: BREAKDOWN

[illegible] PM		15

[illegible] NO.	DESCRIPTION	[illegible]	[illegible]	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
[illegible]	[illegible]	[illegible]	[illegible]															P	P	P	P	P	P					
[illegible]	[illegible] 1	[illegible]	[illegible]															P	P	P	P	P	P					
[illegible]	[illegible] 2	[illegible]	[illegible]															P	P	P	P	P	P					
[illegible]	[illegible]	[illegible]	[illegible]																P			P						
[illegible]	2	[illegible]	[illegible]																P			P						
[illegible]	[illegible]																						B	B	B		BB	

P = INSPECTION PERFORMED A: ACTION PERFORMED DURING INSPECTION B: BREAKDOWN

BLDG 46 [illegible] Prj

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CARD NO.	DESCRIPTION	PM	STANDARD HOURS / FREQUENCY	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
118	[illegible] 1	M	4	P	PPB	PA	P	PPB	P								P	PP	PPB	PPP	PPB	P	P	PPB		B		P
119	" 2	M	4	P	PB		P	P									P	PP	PPP	PPP	P	P	P	PP				
120	" 3	M	4														PPP	PPP	PPP	PPP	P	P		PP				
121	" 4	M	4	P	P	P	P	P									P	PP	PPP	PPP	P	P	P	PP	P			
128	" [illegible]	M	.5														P	PPP	PPP	PPP	P	P	P	P	PP			
129	" 6	M	.5		P	P	P	P			PP	PP	PP	P														
[illegible]	[illegible]	W	.5																				PPP	P				
[illegible]	[illegible]	[illegible]	.5																				PPP	P				
[illegible]	"	W	.5																				PPP	P				
[illegible]	"	W	.5																				PPP	P				
[illegible]	[illegible]	W	.5				B																PPP	P				
[illegible]	"	W	.5																				PPP	P				
[illegible]	"	W	.5																				PPPB	P				
[illegible]	"	W	.5			B																	PPP	P				
[illegible]	-	W	.5																				PPP	P				
[illegible]	[illegible]	W	.5																B				PPP	P				
[illegible]	[illegible]	W	.5																				PPP	P				
[illegible]	AC	M	1.0																									
[illegible]	"	M	1.0																									
[illegible]	"	M	1.0																									
[illegible]	"	M	1.0																									
1749	[illegible] 4	Q	.5															P	P	P	PB	P	P					
1750	[illegible] 3	Q	.5															P	P	P	P	P	P					
1751	[illegible] 1	Q	.5						B	B								P	PB	PB	PB	P	P				B	BB
1752	[illegible] 2	Q	.5															P	P	P	P	P	P					
1753	[illegible]	Q	.5	B	B													P		P	PB	P	P					
1754	[illegible]	Q	.5															P		P	P	P	P					
1755	[illegible]	Q	.5	P	PB	P	P		P				P	P		P		P		P	PAB							
1756	"	Q	.6	P	P	P	P	P	P				P	P		P	P	P	?	P	PA		P			B		
1757	"	Q	.6	PB	P	P	P	P	P		P		P	P		P	P	P	PP	P			B			B		P

P = INSPECTION PERFORMED A = ACTION PERFORMED DURING INSPECTION B = BREAKDOWN

BLDG 46 — MACHINE SHOP (?) — PM 17

CARD NO.	DESCRIPTION	FREQUENCY	STANDARD HOURS	1-79	2-79	3-79	4-79	1-80	2-80	3-80	4-80	1-81	2-81	3-81	4-81	1-82	2-82	3-82	4-82	1-83	2-83	3-83	4-83	1-84	2-84	3-84	4-84	1-85
1752	EXHFAN, [illegible]	Q	.4	PP	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
1759	[illegible]	Q	1.0	P	PB	PBBB	P	P	P		P		P	P		P	P	P	P	P	P	P	P		B			P
1760	EXHFAN	Q	.4	P	P	P	P	P	P		P		P	P		P	P	P		P	P	P	P					P
1761	POTATO PEELER	Q	.6	P	P	P	P	P	P		P		P	P		P	P	P	P	P	PB	P	P					P
1762	EXHFAN	Q	.4	P	P	PB	P	P	P		P		P	P		P	P	P		P	PB	P	P					P
1763	STEAM KETTLE	Q	.4	P	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
1764	FOOD MIXER	Q	.5	P	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
1765	MEAT [illegible]	Q	.5	P	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
1766	VEGETABLE [illegible]	Q	.4	P	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
1767	BAKE MIXER	Q	.4	P	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
1768	[illegible] FRYER	Q	.5	P	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
1769	[illegible]	Q	.4	P	P	P	P	PB	P		P		P	P		P	P	P	P	P	P	P	P					P
1770	HVU	Q	.7	P	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
1771	BAKE OVENS	Q	1.5	P	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
1772	[illegible]	Q	.6	P	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
1773	EXHFAN	Q	.6	P	P	PB	P	P	P		P		P	P		P	P	P	P	PBB	PB	PBB	P					P
1774	MEAT SLICER	Q	.5	P	P	P	P	P	P		P		P	P		P	P	P	P	P	P	P	P					P
[illegible]	AC 1	M	2.?															P										
[illegible]	BOILER	?	?	B			BB	B											B								BB	B
	[illegible] FANS									B										B								
	[illegible]						B			B																	BB	PB
	[illegible] HEAT																									B	BB	